ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Vol. XLV. No. 11.

TABLE OF CONTENTS:

ENGINEERING NEWS OF THE WEEK..... 177
Some Recent Notable Train Wrecks (illustrated).... 178
A New Method of Burning Powdered Fuel (illustrated)..... 178
Light Lathes and Screw Machines (illustrated)..... 179
Some Facts Relating to the Asphalt Paving Industry 182
A Water Column for Railway Water Stations (illustrated) 186
Municipal Engineering Work at Milwaukee, Wis.. 187
Expansion in Brick Pavements (illustrated)..... 193
Typhoid Fever in U. S. Military Camps During the Spanish-American War of 1898..... 193
A New Scraping Tool for Dressing Stone (illustrated) 193
Flow in Sewers of the North Metropolitan Sewerage System of Massachusetts 193
State Road Construction in Massachusetts..... 194
Reconstruction of the Missouri River Bridge at Glasgow, Mo.; Chicago & Alton Ry. (illustrated)..... 194
Second Annual Meeting of the American Railway Engineering and Maintenance of Way Association. 197
The "Sunflower" Tunnel Cross-Sectioner (illustrated) 200
EDITORIAL NOTES 188
The Lack of a Sewerage System in Baltimore—Defeat of the "Prevailing Rate of Wages" Law in New York—The Law for the Report of Railway Accidents to the Interstate Commerce Commission—The Sale of the "Atlantic-Pacific Tunnel."
EDITORIAL:
The Defeat of the River and Harbor Appropriation Bill..... 188
LETTERS TO THE EDITOR.....190, 192
Measuring the Magnifying Power of Telescopes—Mending Steel Tapes—Concerning the I. H. Jewell Filter Co——Rapid Earthwork Calculation—Franchises for Electric Railways on Country Roads—The Cassel. Self-Governing Impulse Water-Wheel—The Relative Merits of Garbage Cremation and Reduction—Analysis of Pressure on Foundations of Buildings (illustrated)—Notes and Queries.

THE SEWAGE PURIFICATION PLANT at Madison, Wis., was abandoned on Jan. 2, 1901, on the advice of the city attorney. The council has ordered a suit brought against the bondsmen for the contractors to recover the $25,000 already paid on account of the contract. The city alleges that the plant does not fulfill the contract requirements as to purity of effluent and cost of operation. We are informed by Professor Turneaure that plans for new disposal works were adopted in January, 1901. These plans include septic tanks and coarse filters, all entirely independent of the old plant. The contract for the tanks has been awarded for the sum of $7,020 and the tanks are now being built. Each of the two tanks will be 30 × 120 ft. × 6 to 8 ft. deep, giving a combined capacity of 400,000 gallons. The total daily flow of sewage is about 600,000 gallons, or three times the flow of one of the two tanks. The tanks will be covered. The contract for the tanks was let in advance of that for the filters, in order to get the advantage of the septic treatment by hot weather. The untreated sewage, since Jan. 2, has been discharged by pumping into a small stream connecting two lakes. The present cost of pumping is at the rate of about $2,500 per year. The entire cost of operating the old plant was some $10,000 a year, leaving the net cost of operating the purification works about $7,500 a year. The plant was described in detail in our issue of Dec. 28, 1899. On Jan. 18, 1900, we discussed editorially the abandonment of the plant by the contractors before its acceptance by the city. On Oct. 11, 1900, we abstracted at length an able and interesting report on the operation of the plant by the city, the report having been written by Prof. F. E. Turneaure, Assoc. Am. Soc. C. E., City Engineer of Madison.

A DIGEST OF COMPETITIVE PLANS for the reclamation of the Newark meadows has been submitted to the Board of Works of the city of Newark, N. J., by Mr. Ernest Adam, Engineer of the Street and Sewer Department. There were nine competitors. The three prizes were awarded to C. C. Vermeule, Jas. Owen, M. Am. Soc. C. E., and Alex. C. Chenowith, respectively. The prize plans, and most of the others, proposed dikes, sub-drainage and pumping. Ship canals and the development of water front were included in some of the schemes. One or two plans propose to reclaim the land by filling, some of the material to be excavated from a proposed ship canal. It is understood that the city authorities will consider the advisability of proceeding to drain the meadows under some one of these or some other plans.

THE BROOKLYN BRIDGE TERMINAL question is again before the people of New York city. The Chamber of Commerce has appointed a committee consisting of Morris K. Jessup, Abram S. Hewitt and Charles A. Schieren to investigate the matter of overcrowding at the Manhattan terminal of the bridge with the object of devising some remedy for the intolerable conditions which exist at present. The committee has organized and will employ an expert engineer to study the problem in its various phases and advise with the members in preparing the committee report to the Chamber of Commerce.

TIN-LINED AND LEAD-LINED WROUGHT-IRON pipe is now being made by pouring the melted tin or lead into the iron pipe. It is said that the result is a union of the two metals that is not broken apart even when the pipe is bent. Fittings of the same sort are also prepared. Further information may be obtained from Lamb & Ritchie, Cambridgeport, Mass., who have recently begun to make the new pipe.

THE UTILIZATION OF SAWDUST is the purpose of a machine recently patented in Canada and noted by U. S. Consul-General John L. Bittinger, of Montreal, who does not give the name of the inventor. The sawdust is distilled, and the capacity of the machine is about 2,000 lbs. of wet sawdust per hour; with dry sawdust this capacity is more than doubled. In addition to the gases generated, 1,000 lbs. of sawdust is said to produce the following: "Char," 160 lbs.; acids, 180 lbs.; water, 248 lbs.; tar, 162 lbs. The gases, of which no record was kept as to volume, are claimed to be superior to coal gas for heating and illuminating; but they are unpleasantly pungent without going through a purifier. The inventor is seeking capital, $100,000 being required to properly equip the plant. In Europe some twenty different establishments make oxalic acid out of sawdust; dried yellow and white pine are said to contain 94% of oxalic acid, and oak has 83%.

INDIA RUBBER FORESTS of large extent have been discovered, it is announced, on the banks of the Niera, one of the tributaries of the Amazon. Several German companies have organized expeditions for the purpose of exploring the district, which is situated about eight days' journey from the great tobacco plantations.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on March 7 at Pittsburg, Pa., on the Pittsburg, McKeesport & Youghiogheny R. R. A misplaced switch caused the collision of two locomotives, resulting in the death of one man and the injury of two others.

THE GUARDING OF TROLLEY WIRES has been made the subject of some tests carried out by German Post Office officials at Bielefeld. Copper-guard wires connected to the rail return of the trolley line were stretched above the trolley wire at places where it was crossed by other wires. A telephone wire on falling over the trolley wire first came in contact with the guard wire, which it short-circuited to the trolley wire, causing the automatic cut-out at the station to come into action. This is said to have been so effective that the fuse of the telephone circuit was not blown.

A NEW ELECTRIC ARC LAMP is described in the "Elektrotechnische Zeitschrift" for Feb. 4. The lamp is somewhat similar to the Nernst in that the arc is drawn between electrodes of highly-refractory materials, such as are used in the Nernst incandescent lamp. Very high temperatures are reached and the lamps are very efficient, an economy of 3 to 4 candles per watt being obtained. By increasing the current, and consequently the temperature, an efficiency of 5.21 candles per watt is said to have been attained, but at that point the electrodes commenced to melt. If the figures now accepted for the mechanical equivalent of light are correct this would be very near 100% efficiency.

AN ELECTRICAL PROCESS for manufacturing steel has been perfected, according to the claims of a Swedish engineer, Herr Kjillin, manager of the Gysinge Iron Works. At present he is turning out only about a ton of steel a day, but plans are being prepared for obtaining sufficient power from falls in the river Dalelfuen, a short distance away, where a large generating station will be constructed, after which the steel manufacture will be carried out on a large scale.

COPPER ORE DEPOSITS are being developed on a large scale in the Ducktown District in Tennessee by the Tennessee Copper Co. New crusher houses 100 ft. high have been completed at the Burra Burra and London shafts. Each of these contains a crusher, a rotary screen and a Robins picker belt and is provided with bins having a storage capacity of 500 tons. A standard-gage railroad 7½ miles long, connecting the various shafts, roast-yards and smelters with one another, has been completed. The grades have been so arranged that the cost of handling the empties will about equal the cost of handling the loads. The roast yards will hold 83,000 tons of ore. They have been laid out in benches with double tracks between the benches. A new smelter has been located near Isabella Station on the Atlanta, Knoxville & Northern R. R. It consists of a steel building in which are contained two water-jacketed blast furnaces, 56 ins. by 180 ins. at the tuyeres and 18 ft. from the tuyeres to the charging floor. It also contains two converter stands, an electric crane, clay mill, elevators, etc. The bins have a capacity of 2,500 tons of ore and flux and 750 tons of coke. The material will be conveyed to the furnaces in charging cars drawn by electric locomotives. The power plant contains four 250-HP. boilers, blowing engines, electrical equipment, etc. It is expected that the plant will be running and producing copper by July 1.

BATTLESHIP CONTRACTS have been distributed as follows by the Secretary of the Navy: To the Newport News Co., battleship "Virginia"; to Moran Bros., of Seattle, battleship "Nebraska"; to the Bath Iron Works, the battleship "Georgia"; to the Fore River Works, the battleship "New Jersey" and "Rhode Island." The Cramps will build the armored cruisers "Pennsylvania" and "Colorado"; the Newport News Co. will build the "West Virginia" and "Maryland," armored cruisers; the Union Iron Works will build the armored cruisers "California" and "Dakota"; the Neafie & Levy Co. build the protected cruiser "Milwaukee," and the Newport News Co. the protected cruiser "Charleston." New proposals are asked for building the protected cruiser "St. Louis," bids to be opened on April 4.

THE BELLEVILLE WATER-TUBE BOILER is to be abandoned by the British Navy. The report of the Admiralty committee, which has been investigating this boiler for some time, says:

> The advantages of water-tube boilers for naval purposes are so great, chiefly from a military point of view, that, provided a satisfactory type of water-tube boiler could be adopted, they would be more suitable for the navy than the cylindrical boiler. The committee does not consider that the Belleville boiler has any such advantages as to lead it to recommend it as the best adapted to the requirements of the navy. It recommends, as regards the ships to be ordered, that the Belleville boilers be not fitted in any case, and that in the ships under construction Belleville boilers be not used if work on the boilers is not far advanced. Where a change of boilers would delay the completion of the ships, Belleville boilers should be retained, and they should also be retained in completed vessels.

THE DEVELOPMENT OF AMERICAN COMMERCE, from the administration of Washington to that of McKinley, is treated by the Treasury Bureau of Statistics, excepting four years, until 1877 imports exceeded exports in value; since 1877 the reverse has been the case, with the exception of the years 1889 and 1893, when the excess of imports was $2,730,277 and $18,735,728, respectively. In 1789 the imports and exports figured at $23,000,000 and $20,205,156; in 1900 the imports were $829,019,337, and the exports $1,477,949,666, leaving a balance of $648,930,329 in favor of our exports. The contrast is the more remarkable when we note that in the 107 years preceding the inauguration of Mr. McKinley the excess of exports over imports only aggregated $383,028,497; while in the last four years this excess has reached the handsome sum of $2,150,000,000.

DAY LABOR FOR MUNICIPAL WORK is to be employed as a substitute for the contract system in Chicago, and the city council has directed the Commissioner of Public Works to proceed with the construction of two sections of the intercepting sewers by day labor. Eventually, a bureau of construction will probably be established as one of the branches of the municipal administration.

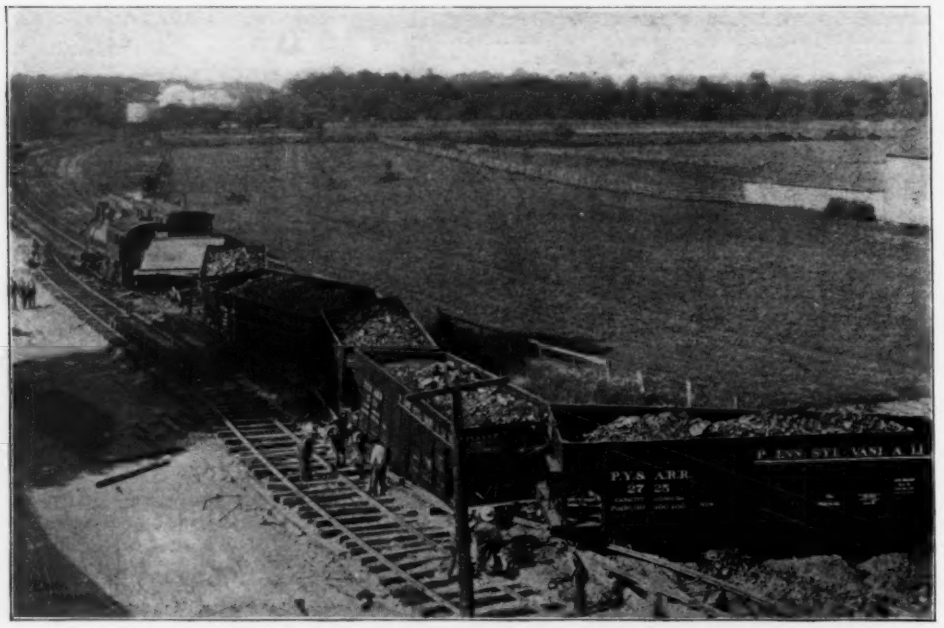
A TURBINE-DRIVEN MERCHANT STEAMER, on the patents of Hon. C. A. Parsons, is being built at Dumbarton by Messrs. W. Denny & Bros. It is intended for the Fairlie-Campbeltown service and was to be completed by July 1. As described by Mr. Parsons in a paper lately read before the Institution of Engineers and Shipbuilders of Scotland, this vessel is 250 ft. long, 30 ft. beam and 10 ft. 6 ins. molded depth to main deck, and 17 ft. 9 ins. to promenade deck. She is somewhat similar to the usual river pleasure steamer in general design. The machinery consists of three separate turbines driving three screw shafts, with the high-pressure turbine on the center shaft and the two low-pressure turbines on the outer shafts. Inside the exhaust ends of the latter are placed two turbines for moving astern; they operate by reversing the motion of the two low-pressure motors and outside shafts. In going ahead, steam from the boilers is admitted to the high-pressure turbine, and after expanding five-fold, it passes to the low-pressure turbines and in them is again expanded 25-fold; it then passes to the condensers, after a total expansion ratio of 125-fold, as compared with 8 to 16-fold in the usual triple-expansion reciprocating engine. At 20-knot speed the center shaft revolves 700 times and the outer shafts 1,000 times per minute. In making a landing or reversing the outer shafts alone are used, the high-pressure shaft revolving idly meanwhile, steam being shut off. The compound main air pumps are worked by worm gearing from the main engines in the usual way, as are the small auxiliary air pumps. There is a feed heater fed from the exhaust steam of the auxiliaries, or from an intermediate point in the expansion of the main turbines. The usual double-ended Scotch boiler is employed. No speed is stated, but the speed is expected to exceed that of any similar boat on the Clyde.

WIRELESS TELEGRAPHY over a distance of 200 miles has been accomplished, according to an announcement made to the Liverpool Chamber of Commerce by Dr. J. P. Fleming. He stated that Mr. Marconi had recently succeeded in establishing communication between St. Catherine's Point, in the Isle of Wight, and the Lizard, which places are the above-named distance apart.

SOME RECENT NOTABLE TRAIN WRECKS.

I. WRECKS OF STEEL CARS.—One of the most common questions raised concerning the steel car when first introduced was how it would behave in a wreck. Prophesies were freely made that it would not only suffer seriously, but that it would be practically impossible for railway companies to repair in their own shops any damage of considerable amount, and it would, therefore, be necessary to scrap any seriously damaged car, unless it were possible to return it to the shops of the builders.

Practical experience with steel cars has now proved that both these ideas were mistaken. The steel car in a wreck has proved itself so much stronger than wooden cars that the latter are the ones to suffer damage, while the steel car comes



DERAILMENT OF TRAIN OF 100,000-LB. PRESSED STEEL ORE CARS ON PITTSBURG, YOUNGSTOWN & ASHTABULA R. R., JUNE, 1900.

off comparatively unharmed. A good example of this is a recent freight collision on the Baltimore & Ohio, where a train was made up of several pressed steel cars, between which were several wooden box cars. The force of the collision was such as to badly crush the wooden cars, while the steel cars were uninjured.

It may be asked, however, whether the steel car will not suffer more when made up in solid trains with no wooden cars to take the shock of the collision. Certainly, it would be reasonable to suppose that smashing would have to be done somewhere to absorb the shock. That these cars stand up remarkably, however, even under such circumstances is shown by the accompanying cut, reproduced from a photograph of a train wreck which occurred last June on the Pittsburg, Youngstown & Ashtabula R. R. (one of the Pennsylvania lines), near Austinburg, Ohio. A train of 100,000-lb. pressed steel cars, made by the Pressed Steel Car Co. and loaded with iron ore, was derailed at a switch and came to a stop in the shape shown in the cut. The tracks were badly torn up and the car trucks suffered some damage, but the car bodies were practically uninjured, as the photograph shows.

When repairs to steel cars become necessary, moreover, experience has developed that the repairs can be made in almost any railroad shop equipped with the usual tools for boiler and tank work and repairs to steel trucks. Thus most railways using steel cars do their own repair work. Had this not been the case it would have been a very serious handicap to the introduction of steel cars.

II. A LOCOMOTIVE LOADED FOR THE SHOP.—Readers of Engineering News may recall a collision which took place on the Old Colony R. R. Jan. 31, 1898, in which two locomotives collided head on, and one landed on top of the other so securely that it was hauled to the shop in that position, the "under dog in the fight" being not even derailed. A somewhat similar accident occurred on the main line of the Pennsylvania R. R., near Coatesville, Pa., on March 6. According to the "Philadelphia Press," a fast passenger train ran into the rear of a freight train and the locomotive landed on top of the coal with which the rear car was loaded, and with so little injury that the car, with its unusual load, was hauled to Coatesville, two miles distant.

III. LOSING A CAR EN ROUTE.—In a magazine story some years ago, the imaginative author has a car loaded with silver leap the track and disappear down the bank unnoticed by the trainmen. A true story of a parallel occurrence on a railway recently built from Monongahela City to the Ellsworth coal fields is reported in the "Monongahela (Pa.) Republican," and we quote from it as follows:

> On Wednesday morning Conductor Bentley's train and crew had as unique an experience as probably ever fell to the lot of railroad men. The train which leaves Bentleyville at noon was a mixed train of passenger and freight cars. Immediately behind the engine were 16 loaded coal cars of the Ellsworth Coal Co., following them was a steam shovel car, truck and shovel, belonging to D. F. Keenan, contractor for the road, which was being shipped to new work at Latrobe. Following this was a freight car and passenger coach. While the train was speeding around a curve the steam shovel car jumped the track and tumbled over the embankment, out of sight, breaking from the freight cars ahead and behind it almost imperceptibly. The gap caused by the disappearance of the shovel car was soon closed by the momentum of the train and the automatic couplers hitched together and the train proceeded. The strange part about it all was that the accident occurred entirely without the knowledge of any of the crew or passengers, and the train drew into Monongahela, some miles distant, where Conductor Bentley was first told of the happening by Telegrapher Ragan, who flagged the train and read the report of the accident, which had been telegraphed by a track walker up the road.

A NEW METHOD OF BURNING POWDERED FUEL.

Many attempts have been made to secure superior boiler economy and smokeless combustion by the use of powdered fuel. It is well known that in the ordinary hand-fired boiler furnace much more air is admitted than is needed for burning the fuel. This surplus air, leaving the boiler at a relatively high temperature, serves only to carry away heat and thus reduce the efficiency of the plant. If air and fuel could be admitted in the exact proportions necessary for complete combustion, thoroughly intermixed and burned before reaching the cold surfaces of the boiler, this loss would be avoided. This has been the principal end sought by the inventors of powdered fuel burning devices.

The economy to be gained in this way would be greatest in comparison with ordinary methods in the case of a boiler with a fluctuating load and poor attendance. If the air supply is cut off from a thick bed of fuel on a grate the combustion thereafter is incomplete and carbon monoxide will be found in the flue gases. On the other hand, if it is attempted to force a light fire with heavy draft, much surplus air will be admitted. In firing powdered fuel the combustible and the air can at all times be properly proportioned to each other and to the load, and, furthermore, the fire may be automatically controlled by the steam pressure.

The first extensive experiments in burning powdered coal were made by Crampton in England in the years 1868 to 1873. He expended a large sum of money and burned about 2,000 tons of coal in testing his apparatus. His plan was to blow the powdered fuel into the furnace by a forced draft. The furnace was lined with firebrick, which, when once heated, served to ignite the incoming fuel.

About five years ago a system invented by Mr. Carl Wegener, a German engineer, was introduced quite extensively in Europe, and was tried in this country. He dispensed with blowers and used only the natural draft of the chimney to carry the finely-powdered coal into the furnace. Numerous tests of his apparatus by eminent European engineers showed boiler efficiencies of 70 to 80%. A quite complete description and discussion of the Wegener system may be found in Engineering News for Sept. 16, 1897.

The system which we are about to describe is the invention of the late William Westlake, notice of whose death appeared in our issue of Jan. 30. Mr. Westlake will be remembered by many railroad men as a pioneer inventor in the field of car lighting with oil lamps, and the founder of the Adams & Westlake Co., of Chicago. The burning of powdered fuel was a subject to which he devoted the last years of his life, and a large part of his work upon it was done after he had became a bed-ridden invalid.

The work of putting Mr. Westlake's invention into practical form and application has been done by the engineering firm of Faber du Faur & Donnelly, 132 Nassau St., New York city. Under direction of Mr. Donnelly a furnace has been installed at the works of Hubbard & Carpenter, 93 Pearl St., Brooklyn, N. Y.

The method of operation adopted in this furnace differs from that of previous dust-burning devices in that a grate is provided upon which a small fire of ordinary coal is maintained. This grate is shown at G in Fig. 1. The pulverized fuel is contained in the hopper H, from which it is forced out through small holes in the bottom by a toothed roller R. The latter is provided with the ratchet wheel W, receiving motion from an oscillating arm, driven through N, by the rocking link L, which is constantly driven by the small steam engine E. When the roller at the upper end of N is at the axis of L it receives no motion, but as soon as it is shifted to the left by the action of the lever M, it is given a vertical movement, the amplitude of which depends upon the amount by which the roller is shifted. The lever M is controlled by an automatic regulator which will be described below. The dust falls in a thin stream down in front of the door D, and is carried under it and into the furnace by the draft. The door D may be raised or lowered any desired amount by means of the hand-wheel, to be seen at the right of the furnace in Fig. 2.

A moderate fire is maintained upon the grate G, where from a third to one-half of the total fuel used is burned. This portion of the fuel may be of any kind suitable for use upon a grate. It is supplied by hand firing at intervals of two or three hours, the door D being raised to permit this. The remainder of the fuel needed to maintain the steam pressure is supplied from the hopper. This supply is automatically controlled in the following manner:

A vertical cylinder is provided in which a counter-weighted piston is acted upon by the steam pressure. When the latter is below the normal the piston is drawn up into the cylinder by the counterweight, which by means of cords and pulleys at the same time opens a damper in the smoke flue, and by means of the arm M sets the dust-feeding mechanism in operation. As soon as the steam pressure rises, the fuel and air are

again cut off. The regulation may be made very sensitive.

The plant above referred to was recently inspected by a representative of this journal. Although the boiler was supplying steam to an engine driving a machine shop in which heavy machine tools were constantly being thrown on and off, there was hardly any appreciable variation of the steam pressure. There was, also, a complete absence of smoke, although the powdered fuel used was prepared from soft coal. The plant at the time was receiving no attention from the fireman.

Experiments have recently been for the first time successfully carried out in burning dust made from hard coal. The chief difficulty heretofore met in burning hard coal arose from the fact that it was not thoroughly enough pulverized.

The obvious disadvantages of any system using dust fuel are the expense of reducing the coal to powder and the complication of the required apparatus. The former is claimed to be not greater than 25 cts. per ton, and to be more than offset by the possibility of using low-priced slack. As for the second point, it is stated that the apparatus above described is cheaper than most mechanical stokers. The relative advantages or disadvantages of the system as a whole as compared with ordinary methods of operating a furnace only extensive experience can determine.

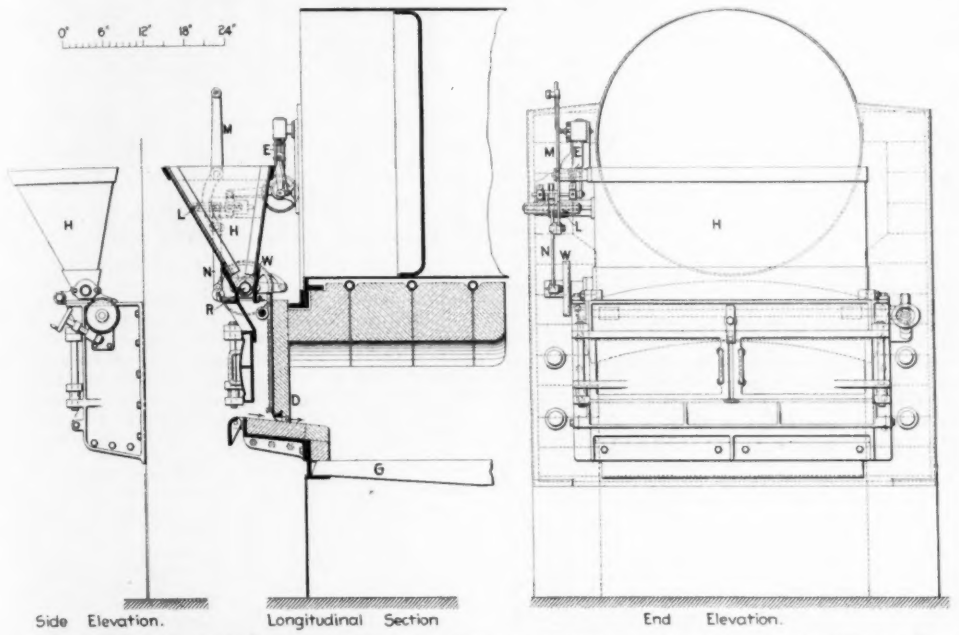
Messrs. Faber du Faur & Donnelly have made a series of tests upon this plant, which are abstracted below, together with their comments upon the same:

These tests were not made to show the highest efficiency which could be obtained with the apparatus and are not to be criticised from that point of view. They were made with the idea of determining what could be expected from the apparatus when working under regular and ordinary conditions, and while the total amount of work done does not vary much from the rating of the boiler there were times when it was much above and below.

The first day some attention was paid to burning as large a quantity of dust as the load would warrant and to burn only as much coal on the grate as was necessary. The second day the practice was reversed and the effect upon the economy is apparent. On the third day the attendance and attention was reduced to a minimum and the conditions made as adverse as it was considered would be met in ordinary bad practice, and the falling off in the result is such as may be expected from neglect and adverse conditions.

These tests were made Oct. 10 to 12, 1900, upon a Beggs return tubular boiler rated by the builders at 35 HP. It had 372 sq. ft. of heating surface, which at 15 sq. ft. per HP. would give 24.8 HP. It was 40 ins. in diameter by 9 ft. long, with a drop leg at the rear. The grate furnished with the boiler had an area of 15 sq. ft.; this was cut down to 9.44 sq. ft. when the dust-feeding apparatus was installed. The coal used on the grate consisted of hard-coal yard screenings containing 2.39% moisture, 4.86% volatile matter, 82.15% fixed carbon and 10.6% ash. The soft coal used in the form of dust contained 1.16% moisture, 29.83% volatile matter, 54.03% fixed carbon and 14.98% ash. Each test lasted about ten hours.

	First day.	Second day.	Third day.
Steam pressure	80	80	80
Temp. of feed water	62° F.	62°	62°
Draft, ins.	½	½	¼ to ¾
Lbs. dust used	574	386	483
Lbs. coal used	368	625	670
Total lbs. fuel	942	1,011	1,153
Total lbs. combustible	801.5	867.39	987.85
Water evaporated	8,050	8,050	7,350
Lbs. water per lb. coal	8.40	7.96	6.37
Lbs. water per lb. coal combustible from and at 212° F.	11.08	11.04	8.85



SECTIONAL AND FRONT ELEVATIONS OF BOILER FURNACE FOR BURNING POWDERED FUEL.
Wm. Westlake, Inventor; Faber du Faur & Donnelly, New York, Engineers.

LIGHT LATHES AND SCREW MACHINES.*

By John Ashford, A. M. I. M. E.

Many changes have taken place during the last few years in the methods of machining in our various engineering establishments and manufactories, changes which are necessary in the march of progress, and which we must and do recognize as essential, in order that we, as a country, may maintain our position in the manufacturing world. These changes in machining methods usually accompany modifications in the schemes of works' management, the object being to systematize the output of the work, so that prime costs may be reduced to the lowest point, while the quality of the productions, as regards both accuracy of size and fineness of finish, may be all that can be desired. In order that these new schemes of organization may be satisfactorily worked and all requirements of the new order of things fulfilled, there has been a demand for machine tools which in themselves shall fit into the scheme, be more handy for their work, be capable of producing numbers of an article exactly alike, be automatic where possible in their action, and shall require little skilled attention. That the changes in themselves are great may be realized when we consider to what an extent milling processes have supplanted shaping and slotting, and, more especially, hand-finishing; how grinding is now used for finishing work that has previously been turned; and, that at present automatic machines are being introduced for producing machine parts in quantities which hitherto had to be made by skilled men at a much higher cost.

In what manner these methods originated it is difficult to say; but, in all probability, they were first introduced in the manufacture of watches and clocks in large numbers; then in the production of small arms, sewing machines, typewriters, and the like; and later in the construction of bicycles. Engineers have now without doubt recognized the fact that similar methods may be employed in the manufacture of larger machines, locomotives, and even bridges and ships. These changes have not been suddenly brought about, although to some it may appear so; but they are the result of steady progress. To those who have not kept abreast of the progressive movements, the changes may have been forced upon their notice with unpleasant suddenness by the experience of foreign competition. Probably there are establishments with which some of our members are connected, where it is realized that alterations in the producing-plant must be made; yet there is hesitation in making the heavy outlay necessary before they have thoroughly considered the matter and are satisfied as to the results likely to accrue.

That the matter is serious is evident from the fact that in certain manufactories whole shops have been cleared of their machines and a completely new and up-to-date plant installed. This paper has, therefore, been prepared in order to create an opportunity for the discussion of the details of machine tools upon which much thought has been bestowed. It is intended that the term "light lathe," as applied in this paper, shall indicate lathes such as engineers use, the centers being about 10 ins. The ordinary lathe with which we were satisfied ten years ago does not fulfil the requirements of the present day. There is no disputing the fact that it was a good serviceable tool, but the necessities of these times demand a machine which may be more smartly worked; be more handy, and cause less loss of time. What then are the requirements of a present-day lathe for tool and ordinary work, and how may these be fulfilled?

Let it be granted as a first principle that the machine should be stiffly constructed, and so lined-up and fitted that initially it may do satisfactory work; then:

(a) Its wearing parts should be made of such material and so shaped, proportioned and protected, that its wear may be reduced to a minimum, and the accuracy of the machine be maintained, and that such wear as takes place may be compensated by adjustments.

(b) The various changes of speed, of traverse, of tool position, of tail-stock position, etc., should be effected by handle-movements which should be practically instantaneous in action and within easy reach of the operator. The use of a spanner for either of these purposes is undesirable.

(c) A reasonable change of speed should be possible without the handling of belts.

(d) All ordinary speeds of traverse should be obtainable without the removal and changing of spur-wheels or belts.

(e) When screw-cutting or chasing from the lead-screw, one movement should suffice to release the screw and withdraw the tool from the work.

(f) When taper-turning, it should not be necessary to disturb the alinement of the tail-stock, or the set of the rest.

(g) Feed stops should be introduced, and also means of reversing the feed-traverse.

(h) It should not be possible for any two speeds of traverse to be in action at one time.

It is difficult to exactly specify the requirements of a turret lathe, as so much depends upon the nature of the work to be machined. It may, however, be conceded, that many of the requirements set forth in paragraphs (a) to (h), apply with equal force to turret lathes, and in addition the following:

(i) When working from the bar, a self-centering chuck must be fitted that shall have sufficient power and range of action to securely grip the bar when subjected to its heaviest cut and allow for ordinary variations in the diameter of rough stock whilst taking its grip without moving the stock longitudinally.

(j) There should be a suitable means of feeding forward the stock when required, without undue loss of time, and it should come into action immediately the chuck is released.

(k) The design of the revolving tool holder or turret should be such as would allow the greatest range of action; hold a sufficient number of tools for all ordinary work; support the tool without spring with the heaviest cuts; bring the tools into action accurately located; simplify the construction and setting of tools and their holders; and revolve and locate itself automatically.

(l) Independent stops should be provided for each tool, and, when the turret traverse is actuated by power, the stops should throw out the power mechanism.

(m) The means of traversing the turret should be such as to allow of quick movements while changing the tool positions, and steady motions while cutting.

(n) A cross slide is usually desirable to carry forming, cutting-off, and chasing tools, and its position should be easily and accurately adjusted.

(o) In many cases, especially for brass work, efficient means of chasing should be introduced, and if, for this purpose, a leader screw is used, excessive wear of the screw should be guarded against.

Full automatic screw machines, suitable for automatic turning in addition to screw-making, may be considered to be modified turret lathes, with mechanism added to automatically regulate the various movements. The requirements of the turret lathe thus apply also largely to this class of machine, and in addition the following:

(p) The headstock should retain some of the features as in the turret lathe, with modifications adapting it to automatic working. The speed of spindle rotation should be variable to a limited extent; but the introduction of self-opening dies has rendered it unnecessary to provide any reversing mechanism.

(q) A cam-shaft must be introduced to regulate the movements of the various parts, and, as the speeds of the movements are required to vary, the cam-shaft speed should be changeable, this speed variation being quite independent of the spindle speed.

(r) It is a debatable question as to whether the turret carrying the tools should have a constant or a variable distance of forw rd traverse. The settlement of this point greatly affects the design of the machine, and, in the author's opinion, the correct answer to the question is, that unless the scope of the machine is to be very much restricted, the forward traverse should be variable.

(s) The mechanism controlling the tool movements should provide for a rapid withdrawal of the tool and change of position, so that idle time may be reduced to a minimum.

The question now is: How may the requirements of the

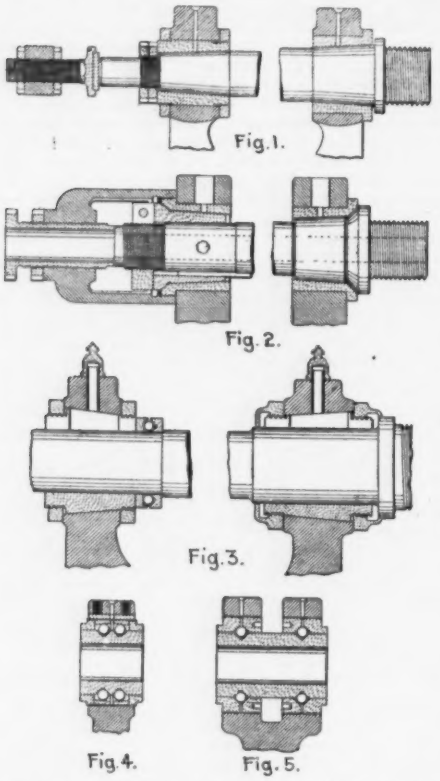
*Abstracted from a paper read before the Institution of Mechanical Engineers of Great Britain, Feb. 15, 1901.

foregoing paragraphs best be fulfilled; and, to what extent do they affect the construction of the machines?

Respecting paragraph (a), the wearing parts which affect the accuracy of the machine are: The journals and bearings of the spindle; the various slides and slide surfaces; the screws and their nuts.

That a wearing surface may act satisfactorily, it is recognized that the following conditions should be fulfilled:

1. That any pressure brought to bear upon it should be evenly distributed.



Figs. 1 to 5.—Different Forms of Spindle Bearings.

2. That it should be protected from dirt of every description.

3. That it should be efficiently lubricated.

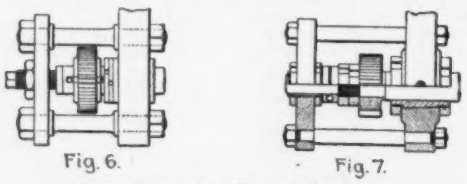
4. That the surface itself should be sufficiently large.

5. And, finally, its formation should not admit of any pressure brought to bear upon it being mechanically increased to any serious extent.

LIGHT LATHES.

THE SPINDLE.—It is a point for debate as to whether the spindle should be hard or soft. In the opinion of the author, it is of much more importance that the bearing surface should be large, and that the journals be made truly cylindrical.

THE BEARINGS.—As materials, each of the following are found to have been used: Hard steel, cast iron, phosphor-bronze and brass or cast iron lined with white metal. When the bearings are small, no doubt hard steel is desirable, but if they are of ample proportions, it becomes unnecessary. Too soft a metal, on the other hand, is not satisfactory, as it does not last well enough. Both phosphor-bronze and cast iron may be considered suitable; that is, if the bearings are well bedded and of sufficient diameter and length to satisfy condition (4) respecting wearing surfaces.



Figs. 6 and 7.—Thrust Bearings.

Several different forms of spindle bearings are shown in Figs. 1 to 5. The conical construction, as in Figs. 1 and 2, has the rather serious objection of failing to comply with condition (5) in regard to wearing surfaces, for, should the thrust-bearing be improperly adjusted, the cone will be forced more deeply in to its bearing, thus increasing the pressure on the surface, thereby creating excessive friction. The cone-bearing, in fact, does not lend itself to either of the conditions (4) or (5), as, with a reasonable taper, the bearing is short; but if, on the other hand, the length is increased, there is a finer taper which still further violates condition (5).

The author prefers the design shown in Fig. 3, where the bearing surfaces are parallel and the exterior of the bearings are coned. The bearing is split in one place and eased in two others, thus making a springy bush which, when adjusted longitudinally, will close upon the journal. This retains the advantage of the cone adjustment with a parallel bearing. In this same bearing, conditions (2) and (3) are well satisfied, there being a felt oiling-pad introduced into the split of the bush and dust-caps over the ends of the bearings. Halved bearings are very largely used, and ball-bearings, as in Figs. 4 and 5, have been tried.

THRUSTS.—With the cone bearing, an adjustable end thrust, such as in Figs. 6 and 7, is necessary; but, when parallel bearings are used, a non-adjustable ball thrust is satisfactory, and it may be placed inside the poppets, thus adding to the compactness of the headstock. A ball end thrust may be seen in Fig. 3.

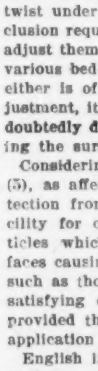
ADJUSTING OR GIB STRIPS.—Several different arrangements of these strips are illustrated in Figs. 8, 9, 10 and 11. Those in Figs. 10 and 11 should undoubtedly be used where possible, and the strip should have sufficient metal in it that only two adjusting screws may be necessary. It cannot be considered good practice to use thin strips with three or more grubscrews for adjustment.

SLIDE SURFACES.—That slide surfaces may wear well, the conditions as to wearing surfaces should be met as fully as possible. When the force applied for the purpose of traversing a slide is not central with the resistance, a couple results with a tendency to twist the slide. A very small angle of twist causes condition (1) to be violated, consequently, unless the strips are so adjusted that there is no slack, the conditions cannot be satisfactorily complied with. This logically leads to the following conclusions:—(1) either the screw or other means of traversing the slides must be in line with the resistance, or (2) where that is impossible, as it usually is, and as an ordinary machine operator cannot be depended upon to keep the strips correctly adjusted, the adjustments must be automatic; or (3) the guide surfaces in contact should be very long. From these points of view it is evident that the nearer a traverse screw is to the center of the slide ways, the better. The usual practice with the slide rest conforms to this, but not so with the saddle, although some firms put the lead screw in the interior of the lathe bed.

Now, as regards the shape of the slide ways of the bed, how do the above conclusions affect their form? As it is impossible to apply the traversing force to the saddle in line with the resistance, and, as it is not desirable to make the guide surfaces so long as would be required by the third conclusion, the second should be considered more closely. That the saddle may have no tendency to twist under the action of the traversing force, this conclusion requires that the guide surfaces shall automatically adjust themselves to each other. On inspecting, then, the various bed-sections illustrated in Figs. 12 to 20 to see if either is of a form that will provide this automatic adjustment, it will be found that those having raised V's undoubtedly do so, for gravity aids as a closing force, keeping the surfaces in contact.

Considering the remaining conditions (2), (3), (4) and (5), as affecting bed sections, condition (2) sequires protection from dirt. A shape which affords the least facility for catching dirt, or, more especially, metal particles which would work in between the rubbing surfaces causing rapid wear, is one having a sloping surface, such as those in Figs. 13, 14 and 16. The possibility of satisfying condition (3) follows on a fulfillment of (4), provided that there are ample means for the continuous application of oil, which is rarely the case.

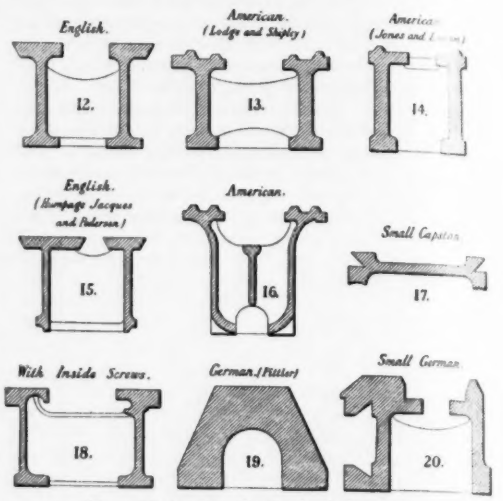
English lathe builders pride themselves upon the ample surface supporting the saddle as obtained by the shape in Fig. 12, which is lost by the use of raised V's. No doubt such a form has the very decided advantage of giving direct support to the saddle and reducing spring to a minimum. The great disadvantage of the raised V form, as in Figs. 13 and 16, is the lack of support for the saddle immediately under the tool rest. The saddle fits upon the two outer V's, and thus has a long span, so tending to make it weak in the back and lacking in stiffness. If, however, the inner V's are placed at a lower level, it allows of an increased thickness in the saddle, which tends to minimize this disadvantage. Moreover, if the cross slide-way is raised upon the saddle, instead of sunk into it, the slide which fits upon it may be of greater length, thus giving a better distribution of the pressure from the tool when cutting, so adding to the stiffness. Such an arrangement has the further advantage of protecting the cross slide-way from metal cuttings. Ample support for the saddle is desirable, but broad slide surfaces on the bed are not unmixed blessings, for they easily catch the metal cuttings which work under the saddle and form the chief factor in the wear of those parts. All things being considered, the author is of opinion that the requirements of paragraph (a) are more nearly met by a bed plate with raised V's, the inner pair being set lower than has hitherto been the practice.



Figs. 8 to 11.—Adjusting or Gib-Strips.

RELEASE-NUT CLUTCH.—The accuracy of the machine for screw-cutting will be affected by the construction of the clutch which operates the release nut. There should be no possibility of side flexure. Figs. 21, 22 and 23 show three ways of constructing this clutch.

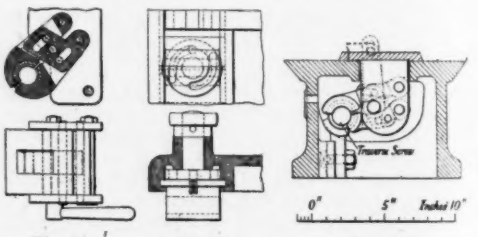
With regard to paragraph (b), it is one of the essentials in modern factories that a cutting tool shall be made to work at as high a speed and with as heavy a cut as can mutually be worked together, which usually means



Figs. 12 to 20.—Lathe-bed Sections.

frequent changes of speed to suit different diameters and variations in cut. The average workman is not, as a rule, particularly keen to get the utmost from his machine, and, the greater the trouble to change the speed, the less often he will do it. It therefore follows that the more easily and quickly a change may be effected, the more likely is the machine to approach its maximum output. This points to the wisdom of making a machine handy, as per the requirements of paragraph (b). How then may these quick variations of speed referred to be obtained? Firstly, in the drive from the main to the countershaft, by using several sets of pulleys or differing diameters, or by friction cone-drives, or expanding pulleys; secondly, with ordinary stepped-cones in the drive to the lathe; and thirdly, with back gearing.

Friction cone drives have been put forward more of late. Messrs. Ward are making a facing lathe which has a



Figs. 21 to 23.—Release-nut Clutches.

chain connection from the cross-traverse screw to the striking fork, so that as the screw is rotated to traverse the slide rest, a motion is transmitted to the striking fork by the chain. The relative motions are so arranged, that when the cutting tool is advanced towards the lathe center, the striking fork is moved to give a greater speed to the lathe spindle, thus maintaining a constant cutting speed.

BACK-GEARING, as originally fitted, was rather troublesome to put into and out of gear, necessitating the stoppage of the machine and the use of the spanner. The introduction of friction back gearing is an improvement which greatly facilitates the change of speed, and is, undoubtedly, a valuable feature in the modern machine, which might with advantage be more generally introduced. A headstock with friction back gear is illustrated in Fig. 24. With a headstock of this description practically an instantaneous change over of the back gearing may be made, and for this purpose friction clutches are introduced into the interior of the belt cone and the large gear on the spindle. These friction clutches are of the expanding brake-strap type, the expansion movement being produced by a simple form of toggle joint, A, Fig. 24.

CHANGES OF TRAVERSE.—A further requirement of paragraph (b) namely, that the changes of traverse should

be effected by a handle movement practically instantaneous in action, is most important, both for ordinary turning and for screw-cutting.

Another requirement of paragraph (b) is that the tool position should be readily changeable, therefore the question we have next to consider is, what movements of the tool are necessary, and how may they be obtained?

That the cutting tool may be brought to an exact position, three directions of motion are essential.

Firstly, in a horizontal plane in the direction of the lathe axis.

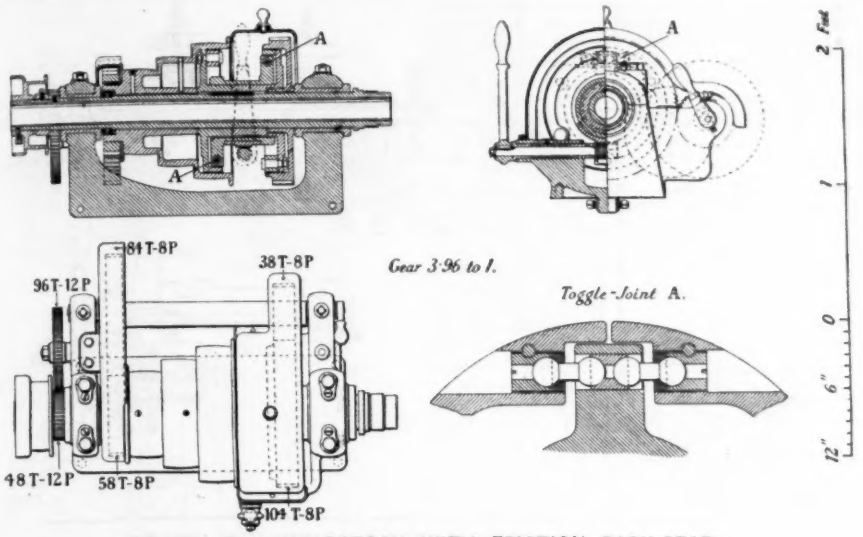


FIG. 24.—8-IN. HEADSTOCK WITH FRICTION BACK-GEAR.

Secondly, in a horizontal plane at right angles to the lathe axis.

Thirdly, in a vertical direction.

As a rule, provision is made for ready adjustment in the first two directions by such means as the compound slide rest; but for the third adjustment, we are rather too familiar with the use of metal-packing strips varying in thickness. What is wanted is a quick vertical adjustment obtainable without loose pieces of any description, for

Fig. 25.—Cross-Slide Apron.

which purpose several firms use elevating cross slide ways, but in most of these arrangements stiffness and rigidity are sacrificed.

A further consideration of the movements of the tool in the horizontal plane, both parallel to and across the line of axis of the lathe, opens up a number of points for discussion, such as the relative merits of the ordinary English saddle with its compound slide rest, and of the apron

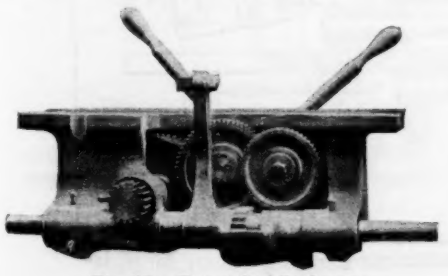


Fig. 26.—Turret-Saddle Apron.

saddle, now being so largely fitted both in America and here.

As regards the English saddle, the longitudinal hand traverse is effected by a rack-and-pinion motion without intermediate gear, and movement so obtained is very jerky and unsuitable for feeding the tool in its cut. Consequently, it is only used for shifting the saddle position when the tool is not in action, and the compond slide-rest is used for hand feed or for fine adustment of the tool.

As regards the apron saddle, the vertical front plate of apron has gearing within it for obtaining the various motions in an easy manner. For instance, there is gearing between the hand wheel and the rack and pinion which gives enough mechanical advantage to enable the operator to give an easy and steady hand traverse to the saddle with fine adjustments, thus rendering unnecessary the compound slide rest.

The abolition of the compound rest necessitates other modifications in the machine, such as cutting away the saddle to clear both the fast and loose headstocks that the tool may get home to the centers. Further, as the fiddle slide of the compound rest is not available to set to an angle for turning tapers, other means must be provided if such work is to be done.

The apron type of saddle has been modified to specially suit the turret saddle and cross slide of the larger types of turret lathes, where automatic traverse is essential. Good examples of such aprons may be seen in Figs. 25 and 26.

On many machines, the loose headstock is constructed in two parts and provision is made to set over the top portion to throw the center out of line and so obtain the taper required. In the author's opinion such a method as this is bad, as, in a machine where accuracy is essential, such accuracy being dependent upon the setting of centers and slides, disturbance should not be permitted when it has once been tested and proved accurate. The only remaining methods of obtaining the taper are, then, either to provide a means of compounding the longitudinal and cross traverses by gearing in any desired ratio, or to use an adjustable former. The first of these two methods is used in a few designs, but it is too complicated, so the latter seems to be the better solution of this problem.

As to the final requirement of (b); of the methods of fixing illustrated in Figs. 27 and 28, the former, although most largely used, requires the objectionable loose spanner, whereas the latter, operated by a handle and eccentric movement, may be considered more satisfactory.

Figs. 29, 30 and 31 show three methods of locking the center slide, and of these the last tends, when locking, to keep the slide in position, whereas the others are likely to spring it out of place.

Regarding paragraph (e); several devices have been introduced for obtaining the double action with one motion. Two of these are illustrated in Figs. 32 and 33.

TURRET LATHES.

In the earlier days of engineering, large quantities of similarly turned articles were not, as now, required; therefore the type of machine evolved at that time was one that could be used for a variety of work, and the chief object sought was general adaptability.

When the need arose for the production of many similar articles at low cost, manufacturers, adapting the machine to their requirements, fitted stops to the slides so that unskilled labor might successfully do the work of turning; but to produce a complete article this often meant a number of chuckings. This system of working may still be found in some factories.

As a further improvement on such a method, the turret form of tool holder was introduced, and that developed into the type of turret lathe with which we are now familiar. It will thus be seen that the modern turret lathe is purely a development of the turning lathe brought about by the necessities of modern manufacturing. The requirements of this type of lathe have already been set forth in paragraphs (i) to (o) and will now be further considered.

CHUCKS FOR TURRET LATHES.—There seems to be some difficulty in designing a chuck which shall comply with all the requirements of paragraph (i), especially when the bar to be operated upon is over 1 in. in diameter. The usual thing is some form of collet chuck, as Fig. 34, together with which is combined a device for obtaining a mechanical advantage and securing a tight grip. The most favored method of operating collet chucks is by the combination of a pair of bell cranks with a sliding cone. Examples of this action are found in Figs. 37, 38 and 42. Other methods are by a system of wedges; by modification of the toggle joint, and by differential screws. The combination of wedges is well exemplified in the Pittler chuck, where there are three wedges arranged in series, together with a rack and pinion, Fig. 35.

A powerful chuck of simple form has been adopted by The Wolseley Co., in which toggle joints are introduced to get a tight grip, Fig. 36.

That applied by Ward (Fig. 44) to their larger type of turret lathes, is a combination of toggles very similar to that introduced by Jones and Lamson in their flat-turret lathe.

Alfred Herbert has introduced the principle of the differential screw in his patent power-operated chuck, which is simple in action, requiring but little effort on the part of the operator, Fig. 45.

The chief fault of most of the collet chucks is that the actual movement of the collet is small; and, moreover, as they must be moved to a given point to lock themselves, they allow of little variation in the size of the stock used. Consequently, as ordinary rolled stock of large sizes varies considerably in diameter, these chucks at times give trouble. The above-mentioned differential-screw chuck locks itself in any position, thus allowing greater variation in the size of the stock than the others and therefore more nearly approaching the requirements of paragraph (i).

STOCK FEED.—With regard to (j), the feeding forward of the stock quickly, yet without shock, is a matter of importance. For light stock, a cord and hanging weight are satisfactory; but, when a weighty bar of metal is to be fed forward, the inertia of the bar is too great for such an arrangement to operate quickly yet without shock, so either a hand or power feed is necessary. Designs of hand feed are shown in the illustrations, Figs. 46 and 47. To manipulate heavy stock, power-operated mechanisms have been fitted by several firms to their machines, Figs. 37, 48 and 49.

TURRETS.—With regard to paragraph (k) respecting the design of turrets, the author holds the opinion that the tendency in the construction of turret lathes has been to

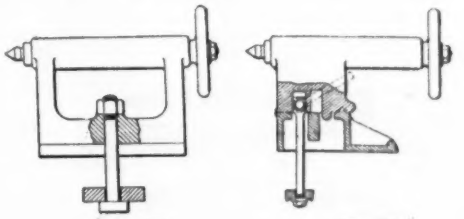


Fig. 27. Fig. 28.

Figs. 27 and 28.—Fixing of Loose-Headstock.

place too narrow a limit upon the possibilities of the machines. This limit is occasioned by the type of turret and the consequent form of tools that have been necessary, the possible length of work being too short and the size of the cut too small.

The flat-turret lathe introduced by Messrs. Jones and Lamson in 1891, correctly known as the "Hartness" flat-turret lathe, was one that was in itself a distinct change and an improvement in turret lathes for producing long

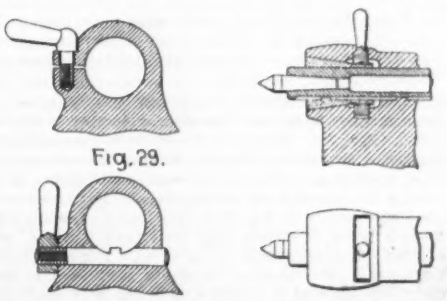


Fig. 29. Fig. 30. Fig. 31.

Figs. 29 to 31.—Back-Center Locks.

work. This machine is illustrated in Figs. 37, 50, 51 and 52. Fig. 37 is a sectional elevation of the headstock, and the other figures show various details of the turret and its mechanism.

THE SWEDISH UNIVERSAL TURRET LATHE has the turret rotating about a horizontal axis, which is mounted upon a cross-slide. The design is reproduced in Fig. 47. With these turrets there are independent stops for each tool brought into position automatically by the same move-

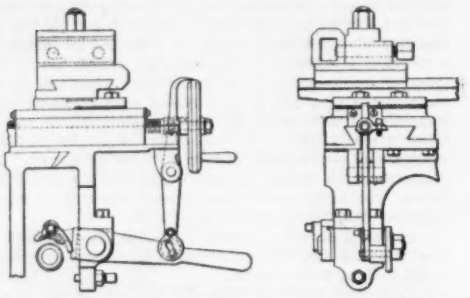


Fig. 32.—Combined Nut-release and Quick-withdraw.

ment which rotates the turret. Details of the rotating and locking mechanism are also shown.

A HOLLOW HEXAGONAL-TURRET LATHE is shown in Fig. 53. The turret is hexagonal that the tool holders may be bolted upon the flats, the cutting tools coming close to the turret face, so that there may be little overhang. The bar being turned may pass through the hollow turret and the possible length thereby increased. The turret is directly mounted upon a saddle which traverses along the lathe bed. The location bolt comes immediately below the flat of the turret carrying the tool in action. To the front of the saddle an apron is fitted containing the mechanism for automatic traverse.

THE CROSS-TURRET LATHE, shown in Fig. 54, has many novel points, the chief of which is the method of mounting the turret. It will be seen that the part of the lathe bed supporting the turret saddle is set back out of the line of the spindle center, so allowing all metal cuttings to fall clear of the ways. The stops are carried by a plate at the rear which rotates with the turret, to bring the stop into position as the corresponding tools come into action. The rotation is effected by a rack that drops into gear with a spur wheel mounted upon the turret spindle when the locking gear is withdrawn. The worst feature about this turret is that the cutting pressure is wholly sustained by the locating pin.

INCLINED-TURRET LATHES have been designed for working upon large castings. Each of these are new tools, in which the details of design seem to comply with all of the requirements of turret lathes excepting paragraph (o), which does not apply to this type of machine.

The work usually turned upon these machines often necessitates the use of long overhanging tools, such as boring bars, reamers, etc. The turret is therefore set over into an inclined position that these long tools may clear other parts of the machine.

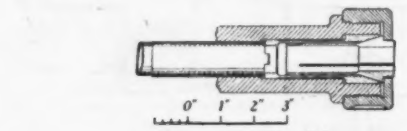
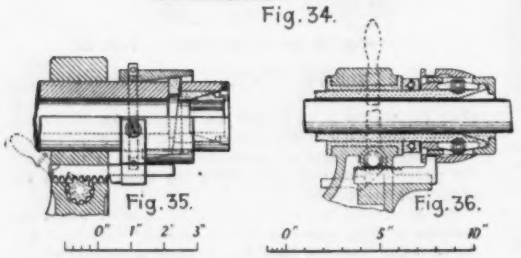


Fig. 34.



Figs. 34 to 36.—Collet-Chucks.

TURRET TRAVERSE.—Paragraph (m) requires that provision should be made for both quick and steady motions. For light turrets a lever or a rack-and-pinion motion, with capstan handles, may be satisfactory; but, when getting to heavier work, some other means of traversing the turret must be introduced. For this purpose the worm gearing in Fig. 55 is very useful when applied to heavier types of turrets that have hand traverse, as it enables a steady motion to be given. For still heavier machines, power-operated traversing gear—such as those described—becomes a necessity, together with some form of automatic tripping mechanism. It is rarely, however, that we find a quick-motion traversing gear introduced for the purpose of changing the tool positions.

CROSS SLIDES.—With regard to the requirements of paragraph (n), the cross slide referred to is of simple construction, suitable for the lighter types of turret lathes, in which all screwing may be done with dies, and the forming operations are simple.

LEADER SCREWS.—Paragraph (o) refers particularly to brass-working turret lathes for making such things as brass fittings, upon which much screwing has to be done. The practice in the past has largely been to provide a rocker shaft at the back, with a chasing arm. the traverse of which is derived from a short leader-screw on the tail end of the spindle; but the threads so produced often vary considerably in size, owing to the spring of the arm.

Dies are often out of the question, on account of the weakness of the material worked, therefore it seems to be the best practice to use a chasing saddle with leader screw in a suitable position for a release nut to mesh with it. By using different screws for the various pitches, the wear will be distributed over a number of screws; and, moreover, the screws being short, they are not very expensive to replace when worn. This is the practice of several firms making turret lathes for this class of work.

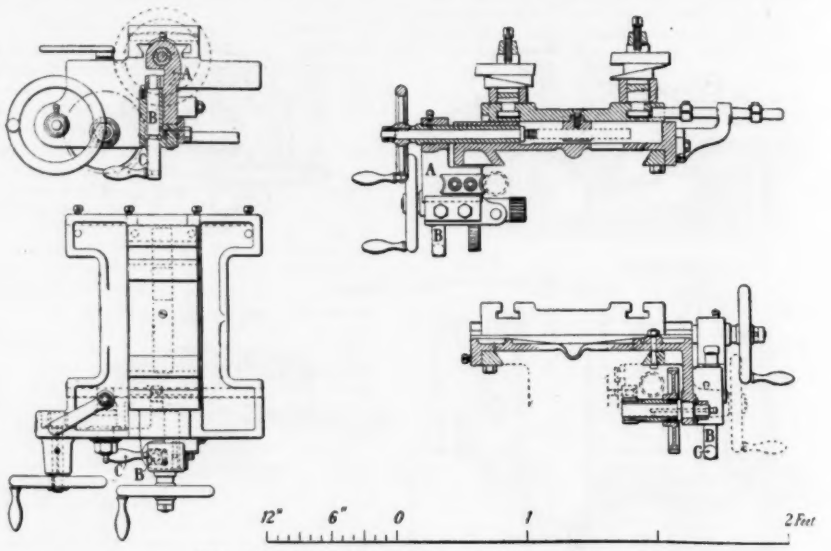


FIG. 33.—CHASING SADDLE OF CAPSTAN LATHE.

FULL AUTOMATIC SCREW MACHINES.

HEADSTOCKS.—With regard to (p), the stock feed as used on turret lathes, requires some degree of modification in its adaptation to the screw machine, and it usually takes the form of a tube with a spring nose-piece carrying the stock, and to which movement may be given by a cam motion. The variation in spindle speed should be such as will suit different kinds of materials of all sizes within the machine capacity; but there is difficulty in getting a sufficient number of changes; consequently, as a rule, two speeds only are introduced, one suitable for turning at the larger sizes, and the other for screwing with a die. It is thus evident that if the machine is put upon brass of a size smaller than its maximum, the economy is doubtful. A discussion of either of the paragraphs (q) (r) (s) is scarcely possible, without touching upon matters affecting the others.

AUTOMATIC TURRETS.—These are arranged on two general systems. In one of these, the turret has a definite and complete range of motion, without the possibility of variation, through which it passes for each tool place, and usually there is a special mechanism with driving gear and cam motion to operate it. In the other, the turret motion is variable from nothing to its maximum, without any special operating mechanism, its movements being derived from a cam drum placed on the same cam shaft, which serves the other parts of the machine.

Each of these systems has its special advantages. The former, for instance, makes it possible to have a central thrust on the turret, which is usually mounted on a horizontal axis, and the controlling cam is easy to make. In the latter, there are fewer wearing parts, and it is simple in construction; but the cams require more skilful setting to work at their best. There is, however, the further advantage, that, as the turret does not require to go through its full traverse for every tool place, whether desired or not, there may be less idle time and less wear and tear.

With regard to paragraph (s). This paragraph expresses the need for rapid change of tool position during such time as the tool is not actually cutting, so that the idle time may be reduced to the shortest possible. When considering this, the question naturally arises: What different speeds of tool motion are necessary? To get the most satisfactory work from automatic screw machines, it is undoubtedly necessary that there should be a very quick speed for change of position; that it should be possible to change the rate of tool feed to a reasonable extent; and that the means of making the changes should be simple.

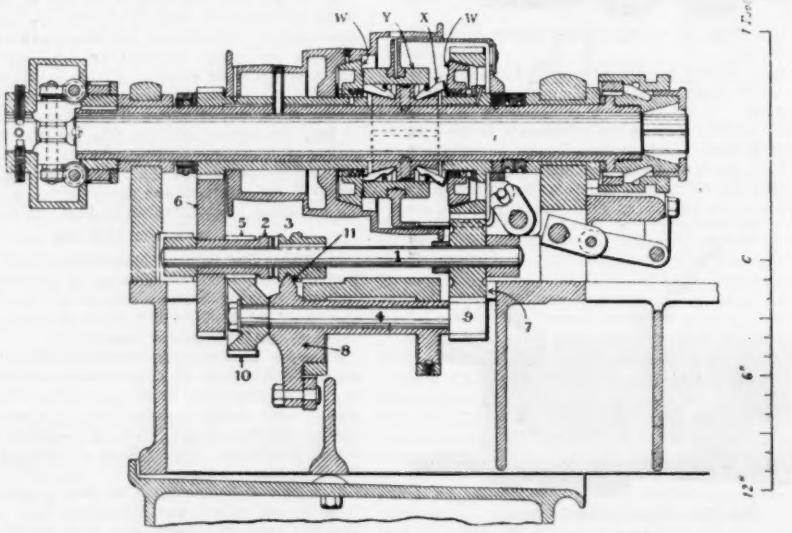


FIG. 37.—HEADSTOCK OF FLAT-TURRET LATHE.

SOME FACTS RELATING TO THE ASPHALT PAVING INDUSTRY.*

By P. W. Henry, Assoc. M. Am. Soc. C. E.†

Thirty years ago there was not a yard of asphalt pavement in the United States; to-day there are about 38,000,000 sq. yds. of sheet asphalt and 2,000,000 sq. yds. of block asphalt, representing an investment by over 200 different municipalities of more than $100,000,000. Asphalt pavements are of two kinds, sheet and block asphalt. Both forms in this country started about the same time. In 1870, Prof. E. J. DeSmedt, a Belgian chemist, laid what was probably the first sheet asphalt pavement

*Condensed from an address delivered before the students of Rensselaer Polytechnic Institute and published in "The Polytechnic."

†Vice-President and General Manager, Barber Asphalt Paving Co., 11 Broadway, New York city.

in this country in front of the City Hall, in Newark, N. J. Trinidad Asphalt was used as the cementing material, and this kind of asphalt has been used in about 85% of all sheet asphalt pavements laid since that date, and in all of the block pavements. In 1869 the first experiments were made in San Francisco with block asphalt, but owing to imperfect machinery the process was not a success until 1880. About that date block asphalt was introduced into Washington, Baltimore, Boston, Chicago, and other cities, since which time it has spread into more than 80 different cities and towns in the United States, and into a dozen foreign countries. In 1876 it was decided to pave

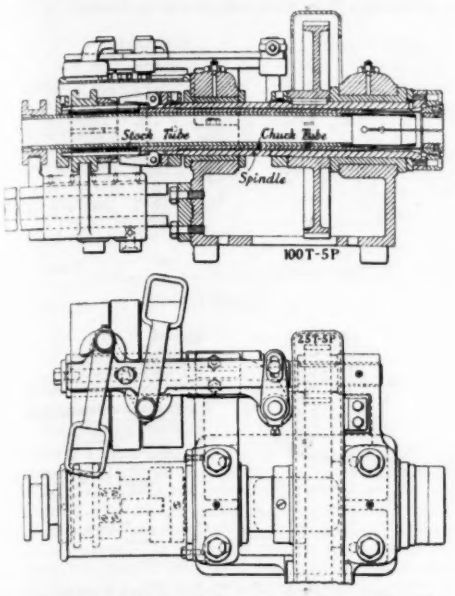


Fig. 38.—Headstock of Automatic Screw Machine.

Pennsylvania Ave., in Washington, and Congress appointed a commission consisting of Generals H. G. Wright and Q. A. Gilmore, of the Corps of Engineers, and Mr. Edward Clark, Architect of the Capitol, to select the best pavement. They received 41 proposals, for stone, macadam, tar and asphalt pavements, but of them all the commission selected two, and decided to pave two-fifths of the Avenue with Neuchatel rock asphalt and three-fifths with DeSmedt's artificial Trinidad mixture.

The Neuchatel asphalt occurs in Switzerland and is fine, amorphous limestone, naturally impregnated with asphalt or bitumen, and is similar in composition to other rock asphalts found in various parts of Europe. Starting with Paris in 1854 these rock asphalts were used in various European cities, but owing to the slipperiness of the material, and possibly to the lack of energy on the part of its promoters, there exist in Europe to-day less than 5,000,000 square yards of rock asphalt pavement. In this country, also, this introduction has been slow. In Washington when it was decided to repave Pennsylvania Ave. in 1889, the artificial Trinidad mixture had proved so satisfactory that the entire street was relaid with this material and the Neuchatel was discarded. Up to the present date about 1,000,000 sq. yds. of foreign rock asphalt pavements have been laid in the United States, and about 500,000 sq. yds. of American rock asphalt, most of which was mined in Kentucky and Indian Territory.

The asphalt industry, therefore, in the United States, is properly that of the artificial mixture as originally devised by Professor DeSmedt. In that case he used Trinidad asphalt but of recent years other asphalts for a cementing material have come into use.

As an illustration of the rapid development of the industry it may be noted that the number of square yards of sheet asphalt pavements laid up to 1880 was 300,000 sq. yds., in 1885 1,800,000, in 1890 8,100,000 in 1895 21,500,000, and in 1900 38,000,000 sq. yds. It must not be assumed that no difficulties arose in the development of the business. Many of the earlier pavements were failures, and it was only by close study and experience that a suitable mixture was finally devised. To-day contractors are willing to lay an asphalt pavement on Lower Broadway, New York city, and guarantee it for ten or fifteen years, whereas ten years ago no contractor would have thought of taking such a risk.

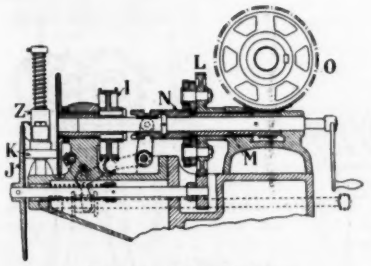


Fig. 40. Cam-Driving Mechanism.

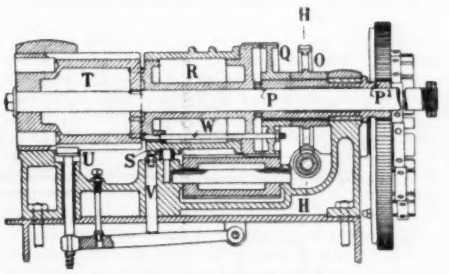


Fig. 41 Turret.

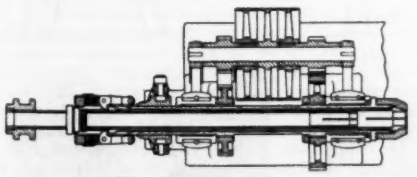


Fig. 42. Headstock, Plan

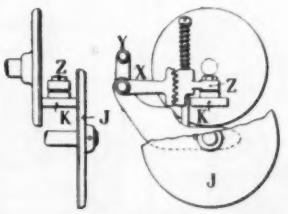


Fig. 43. Friction Gear.

FIGS. 40 TO 43.—DETAILS OF AUTOMATIC SCREW MACHINE (CLEVELAND).

THE FOUNDATION AND THE MIXTURE.

With the exception of the wearing surface, an asphalt pavement is like all other well constructed pavements. It must have a solid foundation, whether of Portland cement concrete, natural cement concrete, macadam, cobble stone or broken stone, every one of which has its value, depending upon the character of the sub-soil and amount of traffic. Upon this foundation is laid first a binder course and then the asphalt wearing surface, the thickness of each course depending upon the amount of traffic. The binder is a mixture of fine broken stone from ¼-in. to 1 in. in size, coated with asphalt cement and laid to a thickness of 1 in. to 1½ ins. The object of the binder is to prevent the shoving or rolling which occurred when the asphalt wearing surface was laid directly upon the hydraulic concrete foundation. The stone is first heated, and while in this state the hot liquid asphalt cement is added in a suitable mixer in sufficient quantity, usually 3% to 4%, to cover each particle of stone. If more than this amount is used the asphalt cement either drains off on its way to the street, or is drawn by capillary attraction into the surface mixture, appearing some months after upon the surface of the pavement in irregular blotches. If too little is used, the particles of stone will not adhere, but the whole mass will break up under the roller.

The wearing surface is that portion of the pavement which sustains the traffic and therefore deserves most careful consideration. As a large proportion, 90 per cent., of the wearing surface is mineral matter it is a very important constituent. From experience it has been found that a silicious sand, of such size that all its particles will pass a ten-mesh screen gives the best results. It is important that the resultant mixture shall be dense and compact; therefore sand grains of one size could not be used, but the sand must be properly graded.

As the 200 mesh material is an important constituent of the mixture and as it is difficult to find in nature a sand so fine, it is customary to grind limestone or quartz until it is as fine as the best grades of Portland cement. Ground limestone is preferable to ground quartz as the limestone seems to have the property of absorbing the asphalt or bitumen, making a tougher mixture than when quartz is used. In the latter case the bitumen does not penetrate, but only coats the outside of the particles.

Although, as stated before, a silicious sand makes the best mixture, yet other sands have been used with good results where the traffic is not excessive. In Santiago de Cuba the sand used is of a calcareous nature, and in Albany, Poughkeepsie and a few other cities it is of a shaly nature.

The quantity of asphalt or bitumen, which cements the particles of mineral matters together, depends not only upon the size of the grains, but also upon the shape and character of each particle. Best results are obtained when each particle is thoroughly coated with asphalt, so that when the paving mixture is compressed under the roller, each particle lies hard against the other with just enough asphalt to act as a cementing material. If too much asphalt is used the pavement becomes soft and mushy and liable to shift under traffic. The excess of

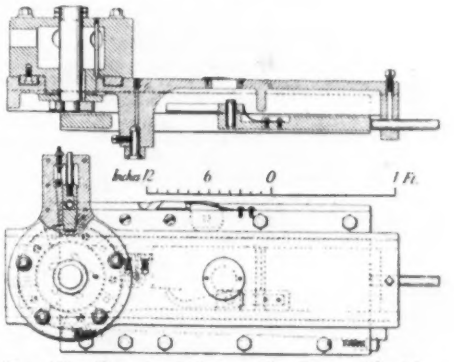


Fig. 39.—Turret of Automatic Screw Machine (Herbert).

asphalt, under a hot summer's sun, becomes a lubricant and the particles of mineral matter slide upon each other. If too little asphalt is used, some of the particles are not coated and the mixture is liable to disintegrate under traffic. In general it is found that a well-graded sand will carry from 10% to 11% of bitumen, or pure asphalt, although some sands, particularly those found along the Platte River, Nebraska, will not carry more than 9%, even though the size of the particles, as shown by the mesh composition, may be the same as another sand carrying 11%. This difference may be due to the shape of the particles and to the character of their surfaces. The surface

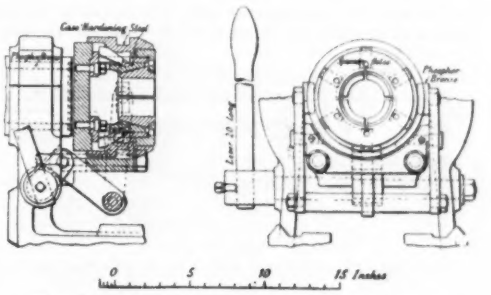


Fig. 44.—Chuck for a 9-in. Flat-Turret Lathe.

of some sand grains may be polished like plate glass, while other grains may have a surface more resembling ground glass.

The exact quantity of asphalt which a given sand will carry is generally determined in a practical way by what is known as the "pat test." In this test a small sample is taken of the hot asphalt mixture (sand and asphalt) and is compressed by hand between two sheets of smooth, brown wrapping paper. If there is sufficient bitumen, the resulting stain on the paper will be scarcely perceptible; if too much, the stain will be blotchy. The proper stain can be learned by experience. In the laboratory, of course, more scientific methods are used, but as the character of the sand may vary from day to day, and in different hours of the same day, it is necessary to have some rapid, practical test which can be applied by the ordinary foreman. As the desired sand grading is seldom found in any one sand, it is usually necessary to mix two, three or even more sands to obtain the required mesh composition. It is necessary to check the sand grading by taking samples of the hot sand after it has been mixed in the heaters.

THE PITCH LAKE OF TRINIDAD.

It will be interesting to examine the occurrence of those asphalts which have been most largely used in the development of the paving business of this country. Chief among them, as it has furnished 85% of the asphalt used in the paving industry in this country, besides largely supplying Europe, Australia, South America and other parts of the world, is the famous Pitch Lake of Trinidad, B. W. I., just off the coast of Venezuela.

This deposit occupies a bowl-like depression, probably the center of an extinct mud volcano, some of which are found in other parts of the Island. It covers about 114 acres, is nearly circular in outline and a little less than half a mile in diameter. The center of the deposit is about three-quarters of a mile from the shores of the Gulf of Paria, and about 135 ft. above the level of the sea, making it easy of access and simplifying the question of shipment. The surface is hard enough, except in irreg-

ular patches in the center, to bear the weight of carts and mules. It is necessary, however, for one to keep moving, otherwise he soon sinks in the material, which under the hot rays of the sun becomes quite mobile, although not sticky, owing to the large amount of water which it contains. The surface of the deposit is divided into irregular areas, from 60 to 150 ft. in diameter, separated by crevices several feet across and from 6 ins. to 6 ft. or more in depth, in which rain water collects and in which fishes, some 6 ins. long, resembling mullets disport themselves. Each of these areas has a motion of its own, from the center to the edge, due to the gas which is being evolved. If a stake is placed in the center of one of these areas it will gradually work to the edge and finally disappear. The crevices are found where the different areas meet, and although the edges of the asphalt in these areas touch each other at a greater or less depth, they do not appear to unite. This deposit has well been called a lake and it possesses the qualifications which such a name would imply. It occupies limits well-defined by shores. From borings made by the writer it appears that the deposit occupies a bowl-shaped basin, the bottom of which 100 ft. from the shore is about 90 ft. from the surface.

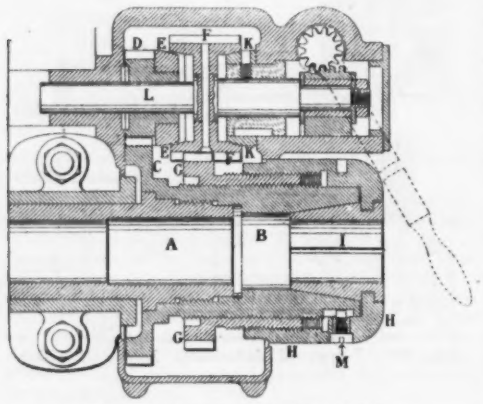


Fig. 45.—Power-operated Chuck.

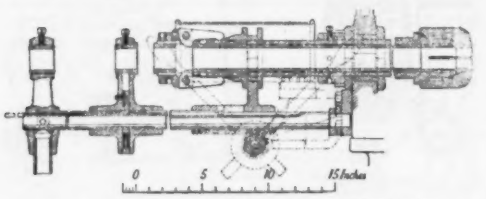


Fig. 46.—Stock Feed and Chuck Mechanism.

The depth in the center is unknown as it was impossible with the implements employed to bore to a depth greater than 135 ft., through all of which the material was that similar to that on the surface. When asphalt is dug from any portion of the deposit, in the course of a few days the hole is filled by new material coming from below, but the entire area of the lake, 114 acres, is lowered in consequence, showing that the mass acts as a liquid, of less mobility however, than water. The composition of the asphalt is of remarkable uniformity, no matter from which portion of the lake it is taken. Samples taken 135 ft. deep at the center did not differ in composition from those taken on the surface a few feet from the shore, showing the homogeneousness of the entire mass. Then, too, the surface is in constant motion. There are on the surface of the lake half a dozen or more islands, from 50 to 150 ft. in diameter, composed of floating vegetation, with trees 30 or 40 ft. high and dense undergrowth. From accurate surveys it was found that one of these islands in one year moved over 25 ft. There are also more rapid movements corresponding to currents and eddies in a lake. In making surveys for the tramway, different lines were run across the lake and stakes put in every 100 ft. These stakes were put in line with a transit and the following day the alinement was about the worst possible. In 20 days one of the stakes had moved 24 ft., or over a foot per day, and other stakes from that amount down to a few feet. This motion is due to the evolution of gas, which is constantly being given off and in some places in such quantities that it can be ignited by a match. Then too, this lake is fed by springs bringing in new material to the amount of at least 10,000 tons per year. Near the center of the lake this soft asphalt appears and spreads over the old and hardened surface. The lighter oils evaporate under the rays of the tropical sun and the new material then becomes hard like the rest of the lake. The resemblance of this deposit to a lake may therefore be summed up as follows. Its occurance in a basin with well defined shores and bottom; its movement as a mass, preserving its level; the uniformity of its composition; the movements of its surface; the presence of islands and the existence of springs.

From levels taken by the writer in February, 1893, and again a year later it appears that the center of the lake is almost a foot higher than the edges. This is probably due to the ebullition of the soft asphalt near the center. Levels have been taken every year since that date and it appears that the lake preserves its contour, although the general level has been lowered nearly 4 ft. in the past eight years. It has been found that the removal of about 18,000 tons of asphalt will lower the level 1 in., and as the output is about 100,000 tons per year the level is lowered from 5 to 6 ins. per year. From the borings, however, it is evident that for several generations to come there will be no shortage. These borings were made with the ordinary portable water-jet machine, such as is used in making borings through sandy material, and it was well suited for the purpose. It took several days to make the borings in the center of the lake, and by that time the casing had gotten so far out of plumb due to the motion of the asphalt, that it was impossible to drive it any deeper. This casing finally disappeared although its top originally stood 6 or 8 ft. above the surface.

The asphalt is dug by means of picks or mattocks just before dawn, when the asphalt is comparatively brittle, and in the early days of the industry was loaded upon carts and taken to the beach, where it was stored until the arrival of vessels, or dumped directly into lighters which carried it to the sailing vessels or steamers, anchored half a mile out from shore. As the business increased it became necessary to install more rapid and economical methods of loading. Surveys for the tramway and pier were made in February, 1893, by the writer, who outlined the plan finally adopted. Detailed plans and specifications were made by L. L. Buck, M. Am. Soc. C. E., and the resident engineer in charge of erection was E. G. Freeman, M. Am. Soc. C. E., and it was finished in the fall of 1894.

The problem was a simple one; 1,700 ft. from the shore of the gulf there is a depth of 30 ft. of water, gradually shoaling to the shore. It was decided to erect a pier 375 ft. long with its outer end 1,700 ft. from the shore. This pier consists of two bridge spans, resting upon steel castings filled with concrete. The bridge work is of light construction, as there is little weight to carry, the pitch lake itself being used as the place of storage. This pier is connected with the shore and pitch lake by the Bleichert overhead cable tramway, supported at intervals of 300 ft. on towers erected in the water, and at less intervals on the shore. The terminus of the overhead cableway is situated on the solid ground a few hundred feet from the edge of the pitch lake. From that point an ordinary cable surface tramway is run out on the lake, supported on a sort of corduroy road made of palm branches, etc. On this surface railway flat cars are used, carrying buckets, which after being loaded are taken to the terminus, lifted by hydraulic power to the hangers and then sent to the pier, where the asphalt is dumped into the hold of the vessel As the heavy buckets go down grade and the light buckets up, less than 15 HP. are required for both overhead and surface cableways. The capacity of the plant is 70 tons per hour, and as there are often vessels on both sides of the pier at the same time, the plant is frequently run to its full capacity.

not soluble in carbon disulphide (which is the solvent for bitumen) the relative quantities being as follows:

Bitumen	40%
Water	28%
Mineral matter	25%
Organic, not soluble	7%
	100%

From this analysis it appears that less than one-half of the crude asphalt as it comes from the lake is bitumen, and that a large percentage is mineral matter. Both of these are essential to a good pavement. In purer asphalts it is necessary to add fine mineral matter artificially, and it is doubtful if as good results can be obtained as when

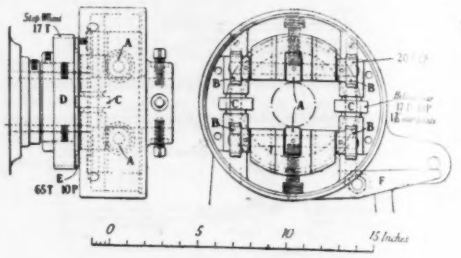


Fig. 48. (Ward)

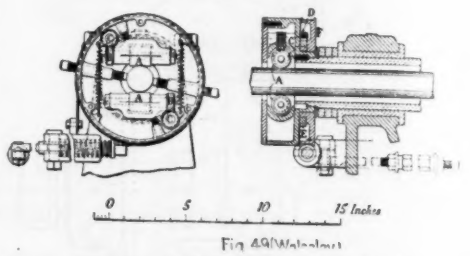


Fig. 49(Waterbury)

Figs. 48 and 49.—Roller Stock-Feeds.

nature had done the mixing. The mineral matter found in Trinidad asphalt is exceedingly fine sand and clay, all of it passing a 200-mesh sieve, and it is mineral matter of this size which is so essential to a good pavement. It is uncertain whether or not the "organic matter not bitumen" is of particular value in a pavement. It does not appear to be deleterious, and probably answers the same purpose as the fine mineral matter.

REFINING AND MIXING ASPHALT.

Water, however, is objectionable and it is the only element which must be removed before rendering the asphalt suitable for paving purposes. This process is generally called refining, but it is more properly a drying process. In fact, all the moisture can be removed by grinding the crude asphalt into a powder and then exposing it to the rays of the sun or putting it in a dry atmosphere, when all the water will evaporate. A process

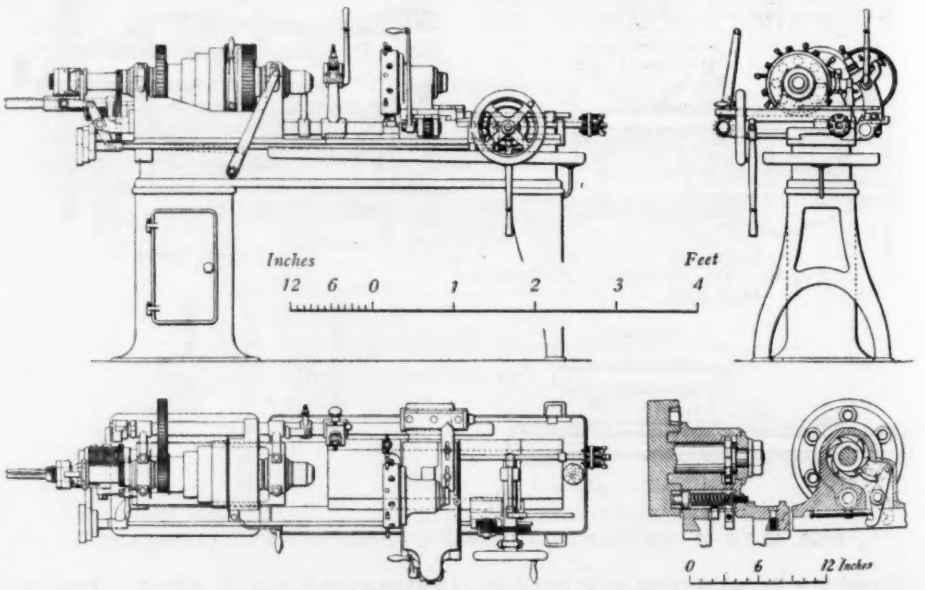


FIG. 47.—SWEDISH UNIVERSAL TURRET LATHE.

There is a small refining plant at the terminus of the cableway, but owing to the higher duty on refined asphalt coming into this country it is cheaper to refine here. Refined asphalt, however, is shipped from Trinidad to Mexico, South America and other foreign countries.

The crude Trinidad Lake asphalt is an emulsion of water, bitumen, mineral matter and some organic matter

of this kind has been patented, but it cannot compete commercially with the ordinary method of subjecting the asphalt to heat. There are two methods of applying this heat: first, the direct action of fire against the kettle or tank holding the asphalt; second, through the medium of steam coils. The first is the old method, and it is still in considerable use although the second method is the one

used in the newer plants. When direct heat is applied, it is customary to put the crude asphalt into cylindrical tanks some 20 ft. long and 8 to 10 ft. in diameter. As asphalt is a very poor conductor, it takes a long while for the heat which is applied to the lower part of the kettle to penetrate the mass, and improvements were made to this form of kettle by placing several large flues through which the products of combustion are drawn. Still even with these flues the time taken to refine a tank

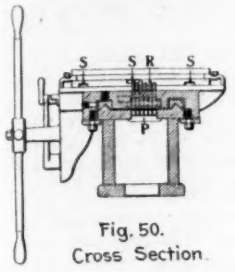


Fig. 50. Cross Section.

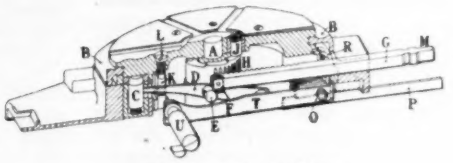


Fig. 51. Turret, Section.

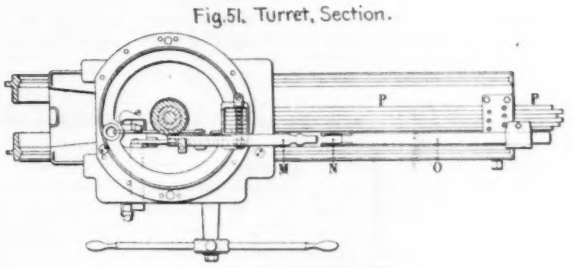


Fig. 52. Turret, Plan.

FIGS. 50 TO 52.—DETAILS OF FLAT-TURRET LATHE.

of asphalt is from six to seven days. During that time considerable of the mineral matter settles to the bottom, forming coke, under the direct heat of the fire so that after every operation it is necessary to thoroughly clean the tank, as the sediment covers the bottom to the depth of a foot or more. In the early days of the industry this sediment was thrown away as it was considered deleterious to the pavement. Now, however, by the new process all of this material is saved and goes into the pavement where it properly belongs.

The second process is a great improvement, not only because it reduces the time of refining from six days to twelve hours, but also because it does away with the pos-

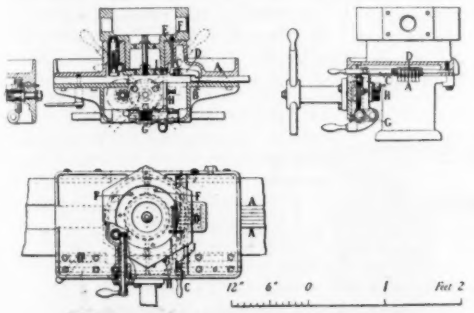


Fig. 53.—Hollow-Hexagonal Turret.

sibility of overheating or burning the material. Under direct heat, through carelessness, the asphalt might become heated to a temperature of 600° or higher, whereas under the new process the heat cannot become greater than that due to the pressure carried in the steam coils. As it is customary to carry a pressure of 100 lbs. the corresponding degree of heat is about 325° Fahr., which is ample. The new process is a simple one. A tank 10 ft. × 10 ft. × 15 ft. high is filled with coils of 1¼-in. pipe not more than 6 ins. apart. These coils are made of extra heavy pipe and are well braced and protected so they will not be damaged by lumps of crude asphalt falling upon them. In one of these tanks there are about 4,500 lin. ft. of pipe, thus ensuring sufficient heating surface. The horse-power required per tank is about 125, and the amount of water evaporated from each charge of asphalt is 28,000 lbs. In order to keep the mineral matter from settling, perforated steam pipes are placed in the bottom of the tank, from which the escaping steam keeps the mineral matter in suspension. At the temperature of refining the asphalt is liquid, and after all the water has escaped, it is run into barrels—generally second-hand cement or flour barrels—and shipped to the paving plant.

Refined Trinidad lake asphalt of itself is too hard and brittle to form the cementing agent to bind the particles of sand together. It is therefore necessary to use a flux to bring the asphalt to the proper consistency. For this purpose petroleum residuum is generally used, although liquid asphalts from California have been used to some extent. Both are pure bitumen. As liquid asphalt is more expensive and residuum has been used for many years with good results, it still remains the fluxing agent in general use. Residuum is a heavy dark oil, resembling the cheaper lubricating oils, and contains none of the lighter oils. Its gravity is from 20° to 22° Beaume, flash point about 450° F., quick flow at 78° F. and containing only a few per cent. of volatile matter in seven hours at 400° F.

In order to make a satisfactory asphalt cement (as the mixture of refined asphalt and residuum is called) it is customary to mix it in the proportion of about 100 parts of refined asphalt to 20 parts of residuum. The asphalt is first melted in tanks and the residuum is then added and thoroughly mixed by agitating with air or steam. As the quality of the residuum varies, it is not possible to gage the exact amount necessary by weight. Samples are therefore taken by the foremen in charge and tested by chewing. By practice a man can become expert in this line, but it is of course necessary to have a standard sample for comparison. At the laboratory and at the larger plants the consistency of the asphalt cement is tested by an apparatus called the penetration machine, and the consistency of the cement is recorded. Other methods for determining the consistency are also in use and each one has its merits. For quick service the chewing test is as accurate as any other, but there is no method of recording its results.

The asphalt cement, which in the tanks is carried at a temperature of 300° to 350° F., is now ready for use, and is added to the hot sand and other mineral matter in a mixer which is simply a box encasing two shafts revolving in opposite directions, on which are blades shaped like propeller blades. The mixture is generally made in batches of 9 cu. ft., and the time of mixing is from a minute to a minute and a half. The resultant mixture is then dumped into wagons, hauled to the street, raked and rolled in the manner with which you are doubtless all familiar, and the asphalt pavement after a few hours cooling is then ready for traffic.

OTHER ASPHALT DEPOSITS.

Having thus briefly considered the preparation of Trinidad lake asphalt, other deposits will be taken up and examined. Outside of the Pitch Lake of Trinidad are deposits of asphalt known as "land asphalt" in distinction to the material coming from the lake. It is of the same general character, somewhat harder and more brittle, and usually lacks the life of the lake material. Some consider that this asphalt is the result of an overflow from the lake, as it occurs at a lower level, being mostly found between the pitch lake and the sea. Its quality, however, is irregular and for this reason, if no other, it has not generally proved satisfactory for paving purposes. Some of it is very hard and is known as iron pitch, other resembles coke and some of it appears similar to the lake material. Considerable of it has apparently been burned through forest fires. Land asphalt occurs in irregular de-

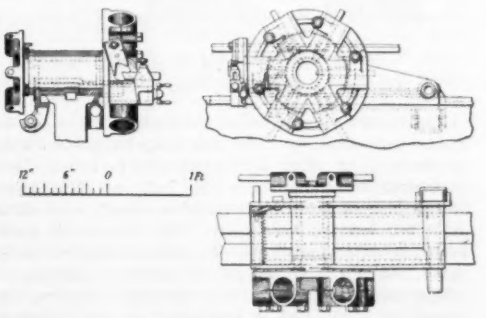


Fig. 54.—Cross-Turret.

posits or pockets with considerable earth and other rubbish. The material taken for shipment is usually selected with considerable care, the coke and foreign matter being cut from the portion which appears to be of good quality. The excavations are carried to a considerable depth and the asphalt from adjoining lots often finds its way into these excavations, giving rise to numerous law suits. As the production of this material is small, no special apparatus is used for loading upon vessels, but the material is carted to the beach and then taken out to the vessels in lighters. This material is refined and treated in a manner similar to the lake asphalt, except that more residuum is required to produce asphalt cement of the proper consistency.

Next to the Island of Trinidad, Venezuela has furnished the largest amount of asphalt used in the paving industry, about 2,500,000 sq. yds. of pavement having been laid with this material. Across the Gulf of Paris about 105 miles due west of the Trinidad Pitch Lake lies the Bermudez asphalt lake, situated in the State of Bermudez, Venezuela. It lies in a straight line about 20 miles from the gulf, but by the San Juan and Guanoco rivers the distance from the bar at the mouth of the river is some 40 miles. The San Juan is a deep, wide river and although there are only 19 or 20 ft. of water at the bar, in the river itself the water is in many places over 100 ft. deep. From the San Juan branches a smaller river, the Guanoco, and three miles from the junction is located the wharf along which steamers drawing 18 ft. of water can lie and receive the asphalt. This wharf is located about five miles from the asphalt lake, to which it is joined by a narrow-gage steam railroad. The lake covers an area of about 1,000 acres, being nine times the area of the Trinidad lake. This larger area does not necessarily indicate a larger amount of material in the deposit, for the asphalt in many places is only from 2 to 10 ft. deep. There are many springs of soft asphalt or maltha, the largest being about seven acres in area. Outside of the springs where new material is constantly exuding, the surface of the lake is covered with vegetation and trees, which must first be cut off to reach the asphalt. The quality of the asphalt varies from the maltha, or liquid asphalt, exuding from the springs to the hard glance pitch which has been produced by fires which during the dry season sometimes sweep across the lake. Underneath the roots of vegetation is the asphalt of commerce, which is handled in much the same way as Trinidad, although it is considerably softer. Its composition also differs considerably from that of Trinidad, and the crude material does not present the uniformity of Trinidad. The crude Bermudez asphalt contains water, but it is present as a mixture and not as an emulsion. In percentage the water varies from 10 to 40%., averaging 31%, whereas in Trinidad asphalt the quantity is constant at 28%. The mineral matter also varies from less than 1% to more than 3%., while the organic matter not bitumen varies from 1 to 6%. An

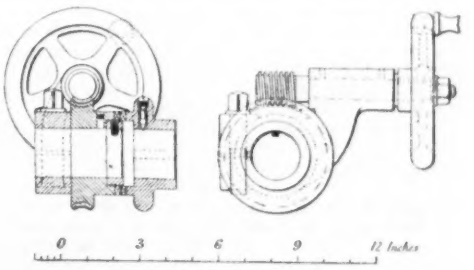


Fig. 55.—Worm-Gearing for Turret Traverse.

average analysis of the crude material from the lake is as follows:

Bitumen	66%
Water	31%
Mineral matter	1%
Organic matter, not bitumen	2%
	100%

In this case, as with Trinidad asphalt, the only element to be eliminated is water, and this is done in the same manner.

The asphalt although considerably softer than Trinidad is dug in a similar manner and loaded into small side-dump cars running on a portable track. These cars are pushed by hand to the terminal station on the shore of the lake, where they are dumped into boxes contained on flat cars. These cars are then taken by the locomotive to the wharf on the Guanoco River, about five miles distant, and dumped directly into the vessel if one is alongside, otherwise they are dumped on the shore of the river, where there is considerable storage place.

As the material is softer than Trinidad asphalt it is necessary to have the hold of the steamer or sailing vessel divided into compartments in order that the material may not move too freely. If this were not done, the sailing vessel would get such a list in sailing for any length of time on one tack that it would be impossible to get her on the other tack and the vessel would finally capsize. This same difficulty to a less extent would also occur in steamers where no provision for bulkheads was made. There is in process of erection at the Bermudez lake a refining plant.

Next in use to Bermudez asphalt is Alcatraz asphalt, about 200,000 sq. yds. of this material having been laid. Alcatraz is a trade name rather than a specific kind of asphalt. This material comes from California, and its occurence is very different from the Trinidad and Bermu-

dex abphalts. In fact, there are no asphalt lakes in the United States, but the material occurs either in veins, similar to coal and other minerals, or it is mixed with sand and the asphalt must first be extracted. Asphalt of certain grades is also produced by driving off the lighter oils from the crude oil found in California and elsewhere.

The Alcatraz asphalt as originally placed on the market was a mixture of hard asphalt taken from veins located at LaPatera and of liquid asphalt obtained from Carpenteria, some 15 miles distant. The hard asphalt contained from 55 to 60% of bitumen, about the same as Trinidad, but was considerably harder. The liquid asphalt was extracted from asphaltic sand by boiling the latter in large vats of hot water. The liquid asphalt would rise to the top, was skimmed off and shipped by railroad to LaPatera. The proportion of liquid asphalt would vary according to the consistency of the asphalt cement desired. Generally it was necessary to add residuum at the paving plant. Finding this method of producing alphalt too expensive, it was decided to extract the asphalt or bitumen from a large deposit of asphaltic sandstone located at Sisquoc, in Santa Barbara county. This sandstone contains from 12 to 18% of bitumen which is extracted by dissolving it in naptha, then piping this solvent to Alcatraz Landing on the coast, 30 miles distant, evaporating the solvent, pumping the solvent back to Sisquoc, where it would be used over again, and running the asphalt or bitumen into barrels ready for shipment. This scheme necessitates two plants, one at Sisquoc and one at Alcatraz Landing, both of them elaborate and the most costly of any asphalt plans in existence.

At Sisquoc, the asphaltic sandstone is quarried by blasting down the open face. An electric crane operated by a dynamo in the main building, loads the rock into a car which is hauled by cable to the hopper over the crushing rolls. These rolls are fluted and the final pair only 3 ins. apart. The crushed rock is then conveyed to the melter, a large steam-heated drum, where it becomes plastic and mushy, somewhat like the hot asphalt paving mixture as it is laid on the street. This mushy material then goes to another drum where it is mixed with the solvent, naptha, containing considerable asphalt which has been dissolved from a previous charge. The material then goes to a settling tank where the saturated solution of asphalt and naptha is drawn off and delivered to a tank at the head of the pipe line, whence it goes by gravity to Alcatraz Landing. The sediment in the settling tank, which still contains some asphalt, is forced by a screw conveyor into another tank where it is further mixed with solvent, until after several operations of this sort the asphalt is entirely dissolved and the sand left clean and white. As the sand, however, is wet with the solvent, the latter must be recovered, and this is accomplished by heating the sand in steam-jacketed drums. The solvent goes into condensers and is then used over again. The clean, dry sand is then conveyed to the dump. At Alcatraz Landing the solution is placed in stills, the naptha driven off and recovered in condensers, whence it is pumped back to Sisquoc and used over again. The asphalt is run into barrels and is then ready for shipment, either by rail or water. For water shipment there is a pier about 800 ft. in length along which vessels can lie.

There are many other deposits of asphalt in California, but with a few exceptions they have not been largely developed. In most cases the asphalt occurs in veins or pockets and must be mined and then fluxed with liquid asphalt to obtain the proper consistency.

In Indian Territory, Texas and Kentucky are deposits of rock asphalt which have been used successfully in laying pavements, after the manner of the European rock asphalts. These materials, however, cannot be used very far from the point of their occurence, owing to the cost of freight. The deposits in Indian Territory have been used chiefly in Kansas City and St. Louis, those of Texas in Houston and San Antonio, those of Kentucky in Louisville. In Indian Territory there are deposits both of asphaltic limestone and sandstone, and in order to make a good pavement these asphalts must be mixed in the proper proportions. In order to use the Kentucky asphaltic sandstones successfully, it is necessary to mix with them various European asphaltic limestones or other asphalts. Several attempts have been made to extract by hot water or naptha the asphalt or bitumen from these asphaltic sandstones, but commercially they have been failures.

In Mexico, along the coast not far from Tampico, have been found springs of asphalt, which in quality resemble Bermudez asphalt, although somewhat softer. These springs, however, give out a limited quantity of asphalt and only occasional cargoes find their way to this country.

It so happens that over one-half of the entire asphalt pavements laid in the United States have been laid by one company. This is largely due to the circumstances under which the industry was originally established, but of recent years many other companies have entered the field. Competition will always prevail, for in every city there is some local contractor who has seen his business laying brick, stone, macadam or other paving material considerably decreased by the laying of asphalt pavements and he therefore naturally adds the laying of this class of pavement to his business. Then, too, the price of asphalt pavement is governed largely by the price of other pavements, and as long as a brick pavement can be laid as cheaply as it is being laid to-day, it will be difficult to get for an asphalt pavement a very much higher price. In general it is found that the property owner is willing to pay a higher price for asphalt pavement than for any other form of pavement, but he is not willing to pay a very much higher price. At present, there is in nearly every city where the large companies are doing business one or more local contractors who are laying pavements in competition.

A WATER COLUMN FOR RAILWAY WATER STATIONS.

In the water columns used for filling tender tanks, one of the most important parts is the valve controlling the flow of water, it being essential that the valve should operate quickly and give a full flow when open. The water column illustrated in the accompanying cut is of the ordinary type, with the vertical pipe revolving in its base casting, and being locked in either position (with its arm parallel with or at right angles to the track) by a lever on the pipe fitting notches in the base casting. The arm may be made rigid, as shown, or with a flexible elbow joint. The standard diameter of the pipe is 8 ins. The base of the pipe is fitted to a packing gland, and rests on a ball bearing as shown. This bearing is kept away from the water space and is easily lubricated, while the balls can be readily renewed.

Fig. 2.—Auxiliary Valve for Gulland Water Column.

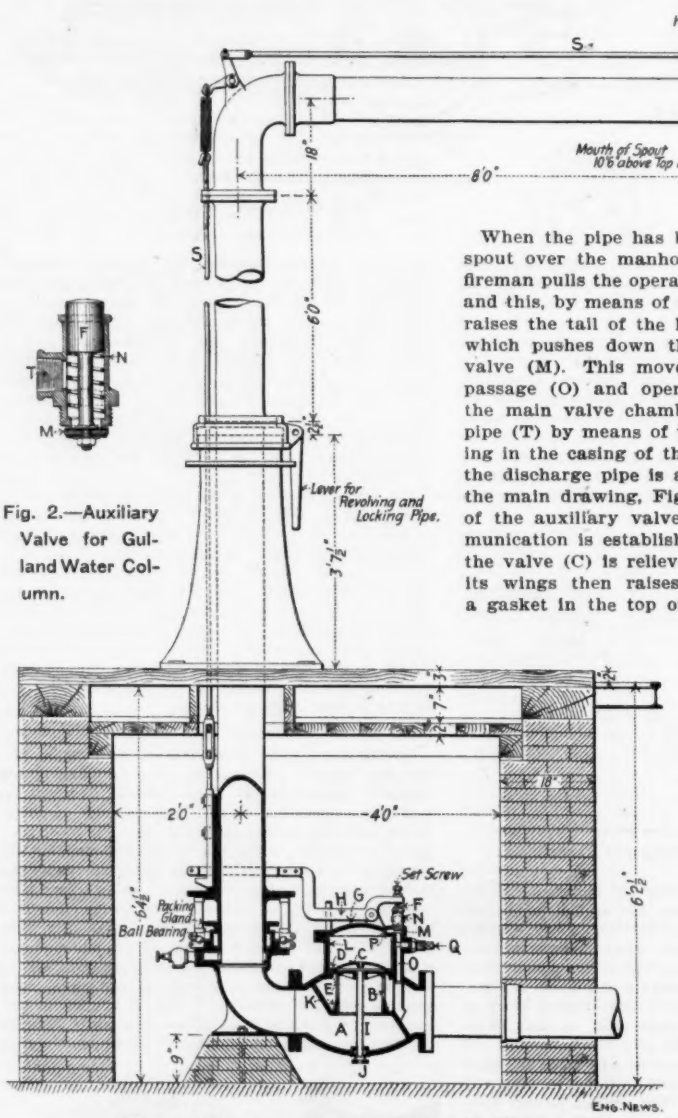


FIG. 1.—THE GULLAND WATER COLUMN.
Best Mfg. Co., Pittsburg, Pa., Makers.

The valve, which is the special feature, is placed in a pit and is connected to the delivery main and to the standpipe of the water column. In the shell or body casting (A) is fitted a stationary bronze piston (B). The top of this forms a seat for the cup-shaped bronze valve (C), which has upper and lower outside wings, shown at (D) and (E). At (F) is the stem of an auxiliary valve attached to the cover (G) of the valve casing, while a lever (H), pivoted to this cover, is connected to the operating lever on the spout and bears on the valve stem (F) by means of an adjustable set screw, by which the speed of operating the main valve is controlled. The hollow stem or pipe (I) is an air pipe for cushioning the valve (C) and its outlet may be fitted with an air valve (J) or with a pet cock. When the valve is seated it takes a bearing upon the leather washer (K) and the wings (D) and (E) form guides and bearing surfaces as the valve moves vertically in its chamber (L), which is fitted with a bronze lining.

The auxiliary valve (M) works in a bronze chamber (N) and opens or closes a passage (O) which extends from the delivery main to the auxiliary valve; and a port (P) which extends from this valve to the main valve chamber (L). The amount of water flowing to the chamber may be regulated by the set screw (Q).

When the pipe has been swung round with its spout over the manhole of the tender tank, the fireman pulls the operating lever (R) on the spout, and this, by means of the connecting rods (S) (S) raises the tail of the lever (H), the short end of which pushes down the stem of the auxiliary valve (M). This movement closes the port or passage (O) and opens communication between the main valve chamber (L) and the discharge pipe (T) by means of the port (P) and the opening in the casing of the auxiliary valve to which the discharge pipe is attached. This is shown in the main drawing, Fig. 1, and also in the detail of the auxiliary valve, Fig. 2. When this communication is established, the pressure on top of the valve (C) is relieved, and the pressure under its wings then raises it until it seats against a gasket in the top of the cover (G). When in this position, the water has a free flow through the body (A) to the water column. To shut off the water, the fireman throws back the lever on the spout, releasing the lever (H), when the spring in the auxiliary valve chamber (N) raises the valve (M), thus opening communication between ports (O) and (P), between the delivery main and the top of the valve (C), when the water pressure forces the valve down, the air under the valve escaping through the hollow pipe (I). The valve on this pipe enables the movement of the valve to be controlled as desired. The water is shut off quickly, and the motion of the valve is checked as it reaches its seat, thus preventing shocks due to sudden seating of the valve.

The valve can be attached to any make of water column. It was designed by Mr. Charles Gul-

land, of Pittsburg, and the device is being introduced by the Best Mfg. Co., of Pittsburg, Pa., to whom we are indebted for drawings and other information. It is already in use on several railways.

MUNICIPAL ENGINEERING WORK AT MILWAUKEE, WIS.

The city of Milwaukee, Wis., has some important municipal works under contract and projected, and the following article has been prepared from notes made by a representative of the editorial staff of Engineering News during a recent visit to that city. The information was obtained through the courtesy of Mr. Charles J. Poetsch, M. Am. Soc. C. E., City Engineer, and President of the Board of Public Works, and Mr. B. W. Perrigo, Assistant City Engineer. The city is divided by its rivers into three districts, each of which is in charge of a Resident Engineer, who makes all the surveys, prepares estimates for street work, etc., and is in general charge of all work in his district. Mr. N. Engel is Resident Engineer of the West District, Mr. E. Kuhlmann of the South District, and Mr. A. E. Retzlaff of the East District. The engineering department has light and spacious quarters in the handsome new City Hall, and there is one room (with three desks) for the use of the Resident Engineers.

BRIDGES.—The present swing bridge over the Milwaukee River at Grand Ave. and Wisconsin St. is to be replaced with a double-leaf bascule bridge, and plans and proposals for this bridge are now being invited. The bridge will be 95 ft. long, with two concrete piers and two masonry abutments (all on pile foundations), leaving a waterway on each side of the main channel. The width of the structure will be 64 ft., including a 36-ft. roadway and two 12-ft. sidewalks outside the main trusses. The location is an awkward one, as the streets are so laid out that the north line of Wisconsin St. (on the east side) almost coincides with the south line of Grand Ave. (on the west side). Besides this, the U. S. Government requires a navigable channel 70 ft. wide between the protection piling of the piers, measured at right angles to the center line of the river. Plans for a bascule bridge at this site were invited once before, but were all rejected. The superstructure of the present bridge will be removed to the site of the Chestnut St. bridge, to replace a lighter structure, which will be broken up.

A new bascule bridge is also to be built at Broadway, giving a channel 100 ft. wide in the clear. The superstructure of the present Broadway bridge will be moved to Lincoln Ave., to replace the present old wooden Howe truss structure. This will require the construction of a new center pier, protection piers and stone abutments at Lincoln Ave.

STREETS.—Brick paving has not been used to a great extent, owing to the unsatisfactory results with some of the early bricks. It is now coming into more general use, however, for business as well as side streets, and also in the manufacturing districts, where it has to carry very heavy traffic. A considerable amount was laid last year, and it is yet too early to give definite conclusions. Brick paving is also used for steep grades on streets that have asphalt paving on the level; this is done to give a better foothold for the horses. Asphalt paving is quite extensively used, and estimates have been prepared for a considerable amount of asphalt and brick paving to be laid during the present year. Under the provisions of a city ordinance, all permanent paving is required to be laid on a concrete foundation. Round cedar block paving has given very poor results, and it is proposed to experiment with rectangular blocks of creosoted pine on one of the viaducts. The present flooring of the viaducts consists of a layer of 3-in. yellow pine planking laid upon the stringers, a layer of 2-in. oak planks laid transversely, and a pavement of 7-in. cedar blocks, giving a total thickness of 12 ins.

STREET RAILWAYS.—The city has not yet enforced the use of grooved rails, but has a considerable part of its city lines laid with 6-in., 72-lb. T-rails, with a toothing course of granite blocks on each side of each rail, between the rail and the asphalt. The inner rows of blocks have the corners beveled to form a groove, and as the blocks are laid upon the concrete, they are not liable to be tilted or displaced. The blocks are 5 × 18 ins., laid alternately as headers and stretchers, but it is proposed to try the use of blocks 5 × 8 ins., and 5 × 5 ins., alternately, so as to avoid the possibility of any tendency to tilt the long stretcher blocks. The street railway company pays for the blocks, and the construction is found to be satisfactory, although, of course, it is acknowledged that grooved rails would be better. The Milwaukee Electric Railway & Light Co. is contemplating very large expenditures for extending its lines and enlarging its power-house and car barns. Mr. John I. Beggs is General Manager of this company.

SEWERS.—During 1900, about seven miles of sewers were built, ranging from 12-in. pipe up to the 5-ft. intercepting tunnel which is being built parallel with the Milwaukee River. A 10-ft. tunnel is also being built northward from the dam, to take the drainage of the northwest section of the city. The 12-ft. tunnel for flushing the Kinnickinnic River with water from Lake Michigan (in the same way that the Milwaukee River is flushed) is now well under way. The tunnel will be 7,300 ft. long, and the first section, 3,300 ft., is finished. The contract for the second section, 1,200 ft., has recently been awarded to Meehan & Courtney, contractors, of Chicago, at $33.40 per ft. They have sunk the first shaft and have started the drifts. The work will be mainly in clay, but pockets of quicksand will probably be encountered. On the first section, the work had to be carried on under air pressure for a length of 300 ft. The pumping plant will be similar to that for the Milwaukee River, consisting of a screw propeller pump driven by a high-power engine.

WATER SUPPLY.—The city's water supply is taken from a crib in Lake Michigan, and is of exceptionally good quality. It is true that all the city's sewage is discharged into the lake, forming a black stream in the clear water, but as the lake currents are to the south (carrying the sewage to Chicago), while the water intake is far to the north of the sewer outlet, there is no trouble from contamination. No important work is planned in this department, but the distribution system will probably be extended about 12 miles, the same as in 1900.

GARBAGE DISPOSAL.—Contracts have been let for the building for a garbage crematory of 150 to 200 tons daily capacity, to be erected on Jones Island. Contracts are soon to be let for the furnaces, which will be on the Engel system. The building will be of yellow brick, two stories high, 80 × 112 ft. in plan. The upper or charging floor will be of concrete, laid between steel floor beams supported by steel columns on concrete foundations. There will be four cremating furnaces, 17½ × 32 ft., each of which will have tanks on the charging floor for holding wet or frozen garbage in the winter. In the charging floor will be circular openings for dumping the garbage into the furnaces. The garbage (with little separation) will be collected by wagons in the city, and the wagon bodies transferred to scows which will be towed out to the plant. This arrangement necessitates the use of two sets of bodies or tanks. There are two main doors in the front of the building, and two sets of overhead trolleys (with 12-in. I-beam runways) form horseshoe loops extending from one door through the building and back to the other door. On these beams will run electric trolleys having two motors, one for a 2-ton hoist and the other for propelling the trolley. Each trolley will have a cage for the operator. At the door a trolley will hoist a wagon body or tank of garbage, carry it to the furnace and dump it. It will then carry the tank to a disinfecting and cleaning apparatus at the rear of the building, and then carry it on to the other door and lower it onto the scow.

In the center of the building will be a smoke-stack 150 ft. high, with a 25-ft. masonry base and a 125-ft. steel shaft, lined with brick. The diameter at the flues is 8 ft. 8 ins., and four radial partition walls extend up to a height of 25 ft. above this level, so as to prevent conflicting drafts or currents. The diameter at the top is 5 ft. The building is located close to the sewage pumping station, and will be supplied with electric power from a generating plant to be installed in that station. In the crematory building will be located direct-connected electric pumps, and direct-connected blowers for the furnaces.

TRACK ELEVATION.—This is a problem which the city now has to face. Where the Chicago, Milwaukee & St. Paul Ry. and the Chicago & Northwestern Ry. enter the city from the south there are numerous grade crossings, and as the land is only 9 or 10 ft. above the water level, depressing the tracks is out of the question. The city wishes to have this piece of line elevated, but the railways and a few manufacturers seem to prefer viaducts. These structures would be numerous and expensive, and would entail additional expense for maintenance and repairs, while elevating the tracks would solve the whole problem at once and ensure a permanent work. Chicago has had this experience, and is now about to pull down some of its viaducts to permit the track elevation to be extended. The distance in Milwaukee would be about 1,700 ft., beginning at the Kinnickinnic River, and the elevation need not be more than 9 ft., the streets being depressed to give a minimum headway of 12 ft., although 14 ft. is considered preferable where electric cars are run through the subways. In the northeast section of the city (18th ward), the tracks of the Chicago & Northwestern Ry. are to be depressed for about half a mile, between Park Place and Lafayette Place. The railway requires a headway of 18 ft., or 21 ft. from rail level to street level; and at first proposed to depress its tracks only 9 ft., which would require the city to raise the street grades 12 ft., and to build inclined approaches at every crossing. This would make an unsightly profile and awkward grade, and would also render the city liable for damages for injury to property on each side of these approaches. The city takes the view that such an arrangement is not permissible, but that the tracks must be depressed the full amount required, 21 ft., leaving the street grades unaltered in most cases.

THE OPERATION OF THE CASCADE TUNNEL, on the Great Northern R. R., is said to be attended with serious difficulties, due to defective ventilation. This tunnel, opened to traffic on Dec. 15, is 13,500 ft. long and the temperature is generally high at all times. A strong air current sweeps through it from west to east, and carries the smoke and gases from the engine with the train going in the same directions, with serious effect upon the trainmen. As the eastbound trains have an up grade of 200 ft. to the mile to overcome, two and some times three engines are used with heavy trains, and this increases the trouble. The authorities are now planning to work this tunnel by electric power, and to generate the power the flow of water from the tunnel—amounting to 1,250,000 gallons daily—will be utilized. By carrying this water a short distance beyond the west end of the tunnel a fall of several hundred feet can be secured. The original plans for this tunnel contemplated the use of electric power in operating it.

A CAR USING "SUPER-HEATED WATER" as a source of power was exhibited to about 50 guests by the Storage Power Co., of New York city, on March 9, when a run was made on the track of the New York Central R. R. from High Bridge to Van Cortlandt Park and back, a total distance of 8 or 9 miles. The car was an elevated railway coach, about 35 ft. in length, which had been fitted with special motor trucks and storage tanks for the hot water. The latter were suspended under the car body and were three in number, each about 24 ins. in diameter and 12 ft. long. These tanks are charged with hot water at about 500° F. at a central station. In operation this water is drawn from the tanks in small quantities at a time and allowed to partly expand into steam at a pressure of 100 lbs. per sq. in. This action takes place in a chamber adjacent to the engine cylinder in which the steam is used. The car on the trial trip was provided with a duplicate engine on each truck, but only one set of engines was used. Motion is transmitted from the crank shaft of the engine to the car axle by spur gears. The Storage Power Co. was incorporated in 1898 with a capital stock of $5,000,000 for the purpose of working the patents of William E. Prail relating to the use of hot water for power storage. As stated by a representative of the company, the above test was for the purpose of showing "that the thing could be done." It is stated that a locomotive will now be constructed of suitable capacity for hauling trains through the New York city tunnel of the New York Central R. R.

ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Entered at the New York Post-Office as Second-Class Matter.
Published every Thursday
at St. Paul Building, 220 Broadway, New York, by
THE ENGINEERING NEWS PUBLISHING COMPANY

GEO. H. FROST, - - - - - - - - - PRESIDENT.
D. McN. STAUFFER, - - - - - - - VICE-PRESIDENT.
CHARLES WHITING BAKER, SECRETARY AND MANAGING EDITOR.
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ALFRED E. KORNFELD, New York,
M. C. ROBBINS, Chicago,
S. B. READ, Boston,
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PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
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Why an American city of over 500,000 population should continue year after year without a sanitary sewerage system, it is hard for people outside of Baltimore to understand. It is a pleasure to note that Mr. James Bosley, Health Commissioner of Baltimore, has devoted a portion of his last annual report to a plea against further postponement of so obvious a sanitary need. A committee of local engineers has made two extended reports on the subject of sewerage, more particularly sewage disposal, but there the matter has dropped. Several propositions to grant a franchise to a private company have been under consideration, but they have not met with general favor and have been abandoned. Meanwhile small towns and villages all over the land are providing themselves with sanitary sewers, leaving Baltimore further and still further in the rear.

Engineers and contractors will be deeply interested in the recent decision of the New York Court of Appeals, declaring that the State Legislature has no constitutional right to require contractors for municipal works to pay the so-called "prevailing rate of wages," and to prohibit any payment by a municipality on account of contract work where the contractor ignores this provision. The court holds that the act deprives both city and contractors of all judgment in the adjustment of wages on public works; prevents master and servant from agreeing on the rate of wages; keeps the city from performing its duties and from keeping within the bounds of constitutional limitations; compels private individuals to pay excessive prices for such improvements as are assessed against abutting property; throws the less competent out of employment, since the poorest laborer, if engaged, must be paid as much as the best; and deprives contractors of the benefits inherent in their contracts.

While the case involved in this decision relates to the employees of contractors only, many of the principles laid down seem to apply equally to employees working directly for the city. As to legislative interference in general, the decision declares that municipalities have some rights that legislatures are bound to respect.

The decision has an important bearing upon the much discussed question as to the relative economy of the day labor plan and the contract system of executing public works. Hitherto in New York, both cities and contractors doing city work have been compelled to pay the "prevailing rate of wages." Under the new interpretation of the law, contractors are freed from this obligation while cities are still bound by it. Inasmuch as the labor leaders have always favored both the day labor plan and the municipal ownership and operation of public utilities, they will do well to have cities also freed from legal wage restrictions.

Report of railway accidents are required to be made to the Interstate Commerce Commission by a bill enacted during the closing hours of Congress. The bill requires reports to be made of all collisions and derailments and all accidents causing injuries to passengers or employees. The "nature and causes" of the accident must be stated, with "the circumstances in connection therewith." The report is not to be made use of as evidence against the railway in any suit for damages.

It is hardly clear whether the purpose of the bill is merely to enable the accident statistics kept by the Commission to be made more complete, or to enable a technical investigation of the causes of accidents to be made. While the latter seems to be intended and is undoubtedly the direction where the greatest benefit might accrue to both the railways and the public, no provision is made for an expert staff to the Commission, which would be necessary to properly handle and interpret such reports.

We have urged in past years that some national bureau should be empowered to receive reports and make expert investigations of railway accidents, to the end that the lessons which they teach might be systematically set forth. Such a system has been carried on for many years by the Board of Trade of Great Britain with respect to accidents on British railways, and more or less work has been done in this direction by a number of our own State railway commissions. The latter work, however, has been inefficient in many ways. No State has railway accidents enough within its limits to employ a force of high-class experts for accident investigation alone, and investigations by others than experts do not carry the necessary weight. It is to be hoped that the new law may be the first step, at least, toward a systematic national record and investigation of railway accidents.

That picturesque old bore, the Atlantic-Pacific Ry. tunnel, near Georgetown, Colo., was sold by the sheriff on March 5 to Jas. E. Ratchford, of Syracuse, N. Y., for $4,100. The tunnel was a scheme of the late "Brick" Pomeroy, and the stock and bonds of the company were sold all over the United States and even in Europe, being purchased chiefly by people of small means. The primary purpose of the tunnel was to tap at a low level certain hypothetical veins of gold and silver ore which the mountain above was supposed to contain; while after completion, it was to serve as a railway tunnel, notwithstanding the fact that it was located at a point where its value for railway use was extremely doubtful. The total length of the tunnel was to be about 18,000 ft., and it is said that a heading was driven in from the east end to about 5,300 ft., without striking, however, the hoped for veins of rich ore.

THE DEFEAT OF THE RIVER AND HARBOR APPROPRIATION BILL.

As briefly stated in our last issue, the River and Harbor bill, carrying appropriations amounting to nearly $50,000,000, failed to become a law before the session of Congress closed at noon of March 4.

The bill as it left the House of Representatives carried total appropriations of about $60,000,000. In the Senate, however, a large number of the items received radical amendment, and the total expenditure was reduced about $10,000,000.

The action of the two houses was then referred to a conference committee, which succeeded in reaching a settlement upon all the matters in which the two houses were in disagreement except four. These four were Senate amendments to the House bill. The first provided for the payment to a private company of $400,000 for some jetties which the company built about ten years ago at the mouth of the Brazos River in Texas; the other three amendments provided for the construction of reservoirs for irrigation purposes in the arid states of the West. The House absolutely refused to accept these amendments, on the ground that the Brazos River appropriation was a wholly unwarranted use of public funds and that the irrigation reservoir items were the entering wedge for enormous appropriations by the government for this class of works. On the other hand the Senate was firm in insisting on these amendments. It will be understood that the representation of the arid land states is much more influential in the Senate than in the House. When the last River and Harbor bill was passed, a determined attempt was made to attach to it some provision for irrigation works, and it was only defeated by a narrow margin. This year the Senators from the arid states were successful in having the irrigation work grafted upon the Senate bill, and they strongly resented its peremptory excision by the House.

Several fruitless attempts were made to break the deadlock between the two houses, until it became evident that if the Senate persisted in these four amendments the bill would fail. This was the situation on the morning of March 4, and the Senate would almost certainly have relinquished its amendments and allowed the bill to pass at that time had not Senator Carter, of Montana, then announced his determination single-handed to defeat the bill.

As our readers will recall, under the rules of the Senate no means exists for compelling the closure of debate. As long as any Senator chooses to occupy the floor, therefore, a vote on a pending measure cannot be reached. It thus lies within the power of any Senator, near the close of a short session of Congress, when the time of final adjournment is fixed by law, to compass the defeat of any measure by merely speaking upon it until it is too late for it to be put to vote.

In the debates on March 3, Senator Carter had occupied much time in denunciation of the bill, and when on the following day the purpose of the Senate to recede from its amendments became evident, he again declared his belief that the bill was a piece of vicious legislation and said:

> So believing, I shall do what lies in my power to prevent the passage of the bill between now and the hour of 12 o'clock. The bill will pass if my strength fails me to such an extent that I can no longer occupy this floor; and I am in a pretty fair state of health!

Senator Carter's opinion of his oratorical durability proved to be well founded. He continued his speech until the hour arrived for the termination of the Fifty-sixth Congress, and the River and Harbor bill, with its $50,000,000 appropriation, failed of passage.

There have been many conjectures as to the Senator's motive for this action. It has been said that he represented the irrigation interests, who are determined to compel the government to undertake work in the arid lands, by obstructing appropriations for navigation work. It has also been said that the bill was killed in accordance with the wishes of the Republican leaders to reduce appropriations and that Senator Carter was merely carrying out instructions. From a careful reading of his long but very interesting speech, however, we are inclined to the belief that he acted on his own responsibility and with the single purpose of defeating what he deemed to be an extravagant and unwarranted use of public funds.

There is no doubt at all that very many items in the bill were for meritorious improvements

which should be carried out. Senator Carter explicitly admitted this; his contention was that these items were so overshadowed by the schemes for work not warranted by commercial conditions, and items inserted merely to help some one with an axe to grind that in the public interest it was better the bill should fail than pass.

A chief feature of interest in his remarks was his indictment of the manner in which the bill was made up. We quote extracts from his speech as follows:

The basis on which this bill and all river and harbor bills for a dozen years have been constructed is vicious. Any Senator who will carefully read this bill and the report on which it is based will inevitably be driven to the conclusion that the bill is framed, constructed and completed upon the despicable principle of division and silence. • • •

• • • You will find that the whim of a member, the demand of a constituency in a locality, rather than the serious engineering aspects of the case has constituted the rule of action.

This bill has become known in the most remote corners of the United States, as the pork bill of Congress. Every man who has a piece of pork in the bill is expected to keep his mouth shut, and to square his conscience with his duty under his oath as best he can. This bill will fail in each Congress in which it is brought up in the future, in my humble judgment, unless correct principles of legislation are employed in the preparation of the bill, and it should fail. Nine-tenths of the items are without merit, without justification.

Men have stood mute upon this floor during the present session of Congress, if I judge correctly, because they wished to get things out of the way of the river and harbor bill. The honest convictions of members have frozen on their lips because they had some trifling river appropriation or some little harbor snap in the river and harbor bill which they wished to bring home to their districts and deliver to their constituents.

You will find these items, generally speaking, not based upon the merits of the respective cases, but generally upon the number of members of Congress from the state. There are about 36 members from New York. I warrant you will find about 36 items in the bill for the state of New York. If you look over the electoral college and determine the number of electoral votes from a state, you can tell about the number of items and the aggregate amount of the items, judged by general proportions, to be found in the river and harbor bill. It does not make any difference whether there is a foot of water or 6 inches of water or no water at all in the river in the state, the appropriation goes there by common custom.

Senators upon the committee will say that these little rivers are of some value in a commercial sense, but I know of my own knowledge that appropriations were made steadily for the improvement of the Yellowstone River in Montana for about twelve years, the sum of $1,600 being appropriated each year, I presume to satisfy the delegate from that territory. There had not been a boat up that river for ten years before, and there never will be a boat upon the river. The water will all ultimately be taken out for irrigating purposes along the bench lands contiguous to the streams. In 1876, about the time of the Custer massacre, the last boat went up the Yellowstone River. For twelve years from 1876 appropriations were steadily made in the river and harbor bill for the improvement of the Yellowstone River. Who did the work, how the money was expended, no one knows. The country was not settled, and I suppose the boys went out there and, finding the fishing pretty good, remained along the stream improving the navigation.

The Mississippi River has been cited as a great highway of commerce, and yet, Mr. President, with all the millions upon millions of money spent upon that river, notwithstanding the fact that the current flows freely and continuously, the railroad running by the riverside carries the freight and carries it cheaper and quicker than the boat running upon the river can carry it. The disappearance of commerce on the Mississippi and upon all rivers in the country can be accounted for by the fact that the improvement in railroading has enabled the railroad people to carry a ton of freight a mile for less money than it can be put upon the steamboat, taken off, and carried between the two points.

It is suggested that the river constitutes a regulation of freights. The perishing—practically—of the towns along tthe Mississippi River, with a few exceptions, constitutes a standing contradiction to that statement. There is no competition by the river with the railroads. As illustrating that, the city of Ottumwa is about 60 miles from Burlington, Iowa. Burlington is on the Mississippi River. A carload of grain will be carried from the city of Ottumwa to the city of Chicago, 186 miles northeast of Burlington, for less money than it will be dropped off at Burlington. Why? Because the railroads discriminate in favor of the railroads and against the river transportation. The river transportation constitutes no check. The Illinois Central road, running up and down the Mississippi, carries the freight. There is only a boat now and then. • • •

One word in closing, about the engineers of the army. It rarely occurs that an engineer of the army reports adversely upon any project he is directed to survey. In my humble judgment therein rests much of the difficulty connected with the preparation of this bill. From time immemorial, throughout the whole history of the army of the United States the Engineer Corps has justly held and has always been entitled to the entire confidence of the country. This confidence has been abused only in very rare cases. The engineers are generally exacting, and possibly in some cases unjustly jealous of the government's interest in enforcing stringent regulations and clauses in contracts. It so happens, however, that in the surveys of proposed improvements of rivers and harbors the feeling of good fellowship in some manner or other intervenes to such an extent that the engineer in reporting softens the truth to the very best of his ability.

So the engineer reporting on Trinity River passed by the artesian well arrangement. He passed by the burning of logs in the middle of the stream during the dry weather in the channel, and he said that this thing could be done for about $4,000,000, and he itemized the expenditure. That report was made because the engineer in charge did not desire to hurt the feelings of the member of Congress in that district.

I imagine that that good fellowship which makes the world akin softened down that report. It seems to me, upon reading the report of the engineer, taking the plain facts as stated by him, it was his clear duty to directly and emphatically and in no uncertain terms condemn this project as not being feasible from an engineering point of view. As the Senator from Maryland suggested, a railroad could be built along the banks of this crooked little stream for half the money it would take to clear the timber from the hillsides, clean the river, burn the logs, put in dams and locks to hold the water raised from artesian wells.

Mr. President, I trust that this criticism, certainly meant in good part, may find lodgment in the mind of every engineer henceforth sent out to conduct a survey and an examination. No engineer would have tolerated a favorable report upon the Trinity River project, or a hundred other of these projects, for a private person. If he had reported to some railroad company that that was an investment that could be considered, he would have been immediately dismissed from the service as a person incompetent or lacking in strength of character to tell the truth when he saw it.

The criticism I have made of the engineers in this behalf is not intended to be unkind, nor do I wish it understood in this closing hour of the session that any remark I have felt called upon to make in connection with the consideration of this bill has been intended to reflect upon any member of either House. I have from the beginning attempted to show that this collection of matter known as the river and harbor bill emanated from a system inherently vicious and destined always to lead to an evil result.

It is the system of swapping—not in a wrongful sense—but in the sense of good fellowship in part, and through a desire to get legislation worked along and made successful. Thus it is that the larger items are diminished below the proper degree, that the smaller items may be provided with something. Where you cannot do anything better for a district, throw a thousand dollars up there to try to improve a stream that never can be of any value for commerce.

These plain statements as to the method by which river and harbor appropriation bills are made up merit serious consideration. The evil undoubtedly exists—perhaps not to so great a degree as Senator Carter claimed, yet to a degree that makes it doubtful whether the harm done by the failure of meritorious projects in this year's bill is not more than balanced by the retention of money in the treasury that would have been wasted had the bill passed. In the Senator's remarks, however, it seems to us that he did not touch the root of the difficulty, nor point out the remedy for it. Is it not a fact that the people themselves are more to blame than either their representatives in Congress or their engineers? When boards of trade and other public bodies unite in urging that this or that or the other improvement shall be undertaken at government expense, is it reasonable to expect their Representative or Senator to tell them that the work would not be of sufficient benefit to warrant its cost? If such a Congressman were found he would doubtless be replaced at the next election by some one who was "willing to work for the interests of his district."

So, too, with the engineers. Their position is a much more difficult one, we believe, than is generally appreciated. It is no light matter for them to antagonize public sentiment in the district where they are located. To say that this or that or the other improvement which the newspapers have agitated until public interest in it is aroused, and which has the backing, very likely, of prominent commercial organizations, is by no means an easy or pleasant thing for an engineer officer to do. It is all the more creditable, therefore, that many officers do have the courage to condemn certain projects as unworthy of consideration. The unfortunate fact, however, is that such brave and honest reports are frequently ineffectual. The pernicious logrolling system, which Senator Carter has so well set forth, takes little account of merit or demerit in a project. Senator So-and-So and delegations from this or that or the other city urge that this or that scheme be shoved into the bill and in it goes, regardless of a report of the engineer against it. With this state of affairs it is little wonder that many an engineer officer decides it to be easier to go with the tide, since an endeavor to stem it is fruitless and only yields him personal discomfort.

But the query returns, What can be done to better present conditions? A few years ago a River and Harbor bill which carried $20,000,000 was deemed cause for public alarm. The "continuing contract" system of work has since been inaugurated under which a large part of the work on river and harbor improvement is provided for in the Sundry Civil Appropriation bill. This year for example, over $7,000,000 was appropriated for river and harbor work in the Sundry Civil bill; yet as stated above, the additional work provided for in the River and Harbor bill which failed amounted to $50,000,000 to $60,000,000. Certainly a halt must be called somewhere. Waste of money on unproductive works is more than a fraud upon the taxpayers. It is a direct cause of financial panic and seasons of hard times. The demand for economy in public expenditures, voiced by the President in his inaugural message, is one that is bound to be heard more and more insistently during the next few years. The government has responsibilities for the maintenance of navigable waterways which it must meet; and these just responsibilities must not be imperiled by an extravagant assumption of huge schemes for works unwarranted by commercial conditions.

The question is then, Where shall we turn to find an authority wise enough and strong enough to rule as to what works are worthy of government appropriations. It is absurd to think that Congress can do this. The task is beyond its physical powers, and the whole thing in its hands has degenerated into a logrolling game. The local engineers have at present not sufficient freedom from local pressure and cannot wield sufficient influence to prevent Congress from overriding their recommendations.

The only road out of the difficulty which we can perceive would be the appointment of a permanent commission to have charge of all the works for navigation improvement undertaken by the government and to be especially empowered to pass upon the merits of every project before presenting it to Congress. With such a commission properly constituted, its recommendations should carry such weight that pressure would not be exerted on Congressmen to override them. Moreover, even if such pressure were exerted, the Congressman could fall back upon the recommendations of this commission, and the eternal demands upon Congressmen to "do something for their district" would be in some measure removed.

It happens that in the very bill which has just been defeated provision was made for the creation of some such body as we have suggested above, and we quote this section of the bill in full as follows:

Section 3. That there shall be organized in the office of the chief of engineers, United States army, by detail from time to time from the Corps of Engineers, a board of five engineer officers, whose duties shall be fixed by the chief of engineers, and to whom shall be referred for consideration and recommendation, in addition to any other duties assigned, so far as in the opinion of the chief of engineers may be necessary, all reports upon examinations and surveys provided for by Congress, and all projects or changes in projects for works of river and harbor improvement heretofore or hereafter provided for. And the board shall submit to the chief of engineers recommendations as to the desirability of commencing or continuing any and all improvements upon which reports are re-

quired. And in the consideration of such works and projects the board shall have in view the amount and character of commerce existing or reasonably prospective which will be benefited by the improvement, and the relation of the ultimate cost of such work, both as to cost of construction and maintenance, to the public commercial interests involved, and the public necessity for the work and propriety of its construction, continuance, or maintenance at the expense of the United States. And such consideration shall be given as time permits to such works as have heretofore been provided for by Congress, the same as in the case of new works proposed. The board shall, when it considers the same necessary, and with the sanction and under orders from the chief of engineers, make, as a board or through its members, personal examinations of localities. And all facts and information and arguments which are presented to the board for its consideration in connection with any matter referred to it by the chief of engineers shall be reduced to and submitted in writing, and made a part of the records of the office of the chief of engineers. It shall further be the duty of said board, upon a request transmitted to the chief of engineers by the Committee on Rivers and Harbors of the House of Representatives, or the Committee on Commerce of the Senate, in the same manner to examine and report through the chief of engineers upon any projects heretofore adopted by the government or upon which appropriations have been made, and report upon the desirability of continuing the same or upon any modifications thereof which may be deemed desirable.

The board shall have authority, with the approval of the chief of engineers, to rent quarters, if necessary, for the proper transaction of its business, and to employ such civil employees as may, in the opinion of the chief of engineers, be required for properly transacting the business assigned to it, and the necessary expenses of the board shall be paid from allotments made by the chief of engineers from any appropriations made by Congress for the work or works to which the duties of the board pertain.

We believe that this simple proposition—which unfortunately falls with the bill of which it formed a part—offers greater possibilities of reform in the conduct of the government's works for the improvement of navigation than any measure since the "continuing contract" system was established, and it might even outrank that in its public benefits.

It seems incredible, and yet it is a fact that with all the hundreds of millions which the government has spent on the improvement of waterways, no such thing as a definite plan for the works as a whole exists or has ever been made. The policy of the government is wholly undefined and the decision whether a particular work has been undertaken or not has simply depended on the question whether there was influence enough to secure an appropriation, and whether there was "pork" enough to go around.

It is time a halt was called. Some definite investigation and determination should be made of the government's policy in the matter. It is absurd to suppose that every river in the country with water enough to fill a lock is eventually to be made into a system of slack water navigation at government expense. It is equally absurd to suppose that at every possible site on the Atlantic and the Pacific, the Lakes, the Rivers and the Gulf, the government is eventually to dig out and maintain a harbor. Work on such a scale would make the nation bankrupt; yet this is exactly the result to which the present system of letting local demands and local influences swell the total of the nation's expenditures directly tends.

In some of its details the plan proposed may be criticised. It would seem to us, for example, that a larger body, constituted partly of civilian engineers and made more independent of the chief of engineers, would carry greater weight with the public and would be less likely to be overruled. Yet any system of any sort is infinitely preferable to the present happy-go-lucky plan of framing river and harbor bills.

Finally, as we have said above, we cannot judge as to the comparative weight of public injury and public benefit which the defeat of the recent River and Harbor bill will cause. If the vigorous speech which killed the bill, however, shall direct public attention to the iniquities of the present system, or lack of system, and shall eventually lead to the establishment of an expert body for fixing government policy and practice in the improvement of waterways, Senator Carter's long-distance speech will have achieved its greatest measure of benefit.

LETTERS TO THE EDITOR.

Measuring the Magnifying Power of Telescopes.

Sir: In your issue of March 7, I noted with interest Mr. William Nelson's description of a method of determining the magnifying power of telescopes.

It might interest those who try it without the photographic attachment, to know that the use of a reading glass in observing the eyepiece for the appearance of the gage across the field will prove a great help. I have also found it easier to pass a fine stick (toothpick) across the center of the objective till the point appeared just in contact with the edge of the field, the stick appearing as a bar across the circle of bright light. The regular vernier reading glass used at the ocular makes it very easy to note when the gage has passed exactly across the aperture. Take the diameter of the bright circle of light in the eyepiece, using the reading glass and a pair of hair-spring dividers; then apply the latter to a fine scale.

I believe this method will be found nearly as accurate as the ingenious photographic one described by Mr. Nelson.

Truly yours, H. Van Duzee.

427 Walnut St., Philadelphia, March 11, 1901.

Mending Steel Tapes.

Sir: I have been interested in the several articles that I have seen in the Engineering News on the repair of steel tapes. Permit me to say that I have used and repaired steel tapes and the chain tape for a number of years, and that my repair kit is so cheap and handy that I repair all of my tapes in the city rather than go to the trouble of taking them to the shop, and always take my repair kit into camp with me. My repairs are made with the aid of a couple of blocks of wood, a darning needle and a few pins in the following manner: Drive a darning needle through a small block of wood; break off both ends, so that they project a little beyond the wood. You then have a small punch, supported through nearly its whole length by the wood. With this punch four holes in each end of the broken tape; and through these holes punch corresponding holes in the small piece of tape you use to rivet the ends together. As you punch each hole thread a large pin through the hole, saw it off with your jack-knife and rivet it down; then proceed with the next in the same way. The whole job will not take as long as it has taken to write this. Sincerely yours,

Topeka, Kan., March 4, 1901. P. L. Wise.

Concerning the I. H. Jewell Filter Co.

Sir: We have repeatedly had called to our attention the fact that Ira H. Jewell, of Chicago, Ill., represents himself as being identified with the Jewell filter, and also represents himself as being backed financially by his father, O. H. Jewell, of the O. H. Jewell Filter Co., of Chicago. We called Mr. O. H. Jewell's attention to the matter, and he makes the following statement, which we wish you would give as prominent a place in your paper as possible:

Chicago, Ill., Feb. 20, 1901.

To Whom it May Concern:

It having frequently come to my notice that Ira H. Jewell, my son, is representing himself as identified with the "Jewell Filter," manufactured by the O. H. Jewell Filter Co. and with myself as his financial backer, I find it necessary to publicly state that the said Ira H. Jewell has had no connection whatever with the O. H. Jewell Filter Co. since selling his stock interest therein over one year ago, and never with its successors in the filter business, the New York Continental Jewell Filtration Co.; nor has he any business relations with me of any description.

Any statements of his, or those of his representatives, that he is authorized to do business of any sort for the O. H. Jewell Filter Co., or its successors as above, are unqualifiedly false and without foundation; and if made, are done so with the deliberate intention to deceive.

(Signed) Respectfully yours,

O. H. Jewell, Western General Manager, N. Y. Continental Jewell Filtration Co.

We would call the attention of those interested in filters to the name of Ira H. Jewell's company, the I. H. Jewell Filter Co., as it is so much like the O. H. Jewell Filter Co. as to be misleading. The I. H. Jewell Filter Co. has no connection whatever with the O. H. Jewell Filter Co., or the New York Continental Jewell Filtration Co., nor the Standard Jewell Filter, which we manufacture and sell and the patents of which we control. Yours very truly, N. Y. Continental Jewell Filtration Co.,

Geo. E. Burroughs, Secretary.

Mills Building, New York city, Feb. 26, 1901.

Rapid Earthwork Calculation.

Sir: Referring to the correspondence on "Rapid Earthwork Calculation" in Engineering News of March 7, 1901, the writer desires to make one correction and two explanations. Mr. Gillette insists that the prismoidal formula is incorrect in some cases and cites Henck's "Field Book," p. 110, in proof. That citation is unfortunate. The illustrative example there used does not show the prismoidal formula to be inaccurate, but shows the method of equivalent level sections to be inaccurate. Henck says the same thing explicitly on the same page. The prismoidal formula will give the same result as Henck's if consistently used. But in computing midsections for the prismoidal formula it must be remembered that Henck's formula is based on the assumption that the surface is composed of plane triangles and not warped surfaces. Midsections are more easily computed if the surface is warped, but if so done, the results will sometimes be larger and sometimes smaller than by Henck's method. In other words, two formulas, both of which are correct, must not be expected to give the same results unless applied to the same solid.

The writer's reply to the last clause of Mr. Gillette's second paragraph is that he would not use the prismoidal formula, but the mean areas formula with prismoidal correction formula. The prismoidal correction formula is so arranged that inspection will determine whether it needs to be used. If either factor $(c_0 - c_1)$ or $(D_0 - D_1)$ is zero the correction is zero; if both are small or one is very small, the correction is small and one can quickly decide whether to compute it or to neglect it.

As to tables "prepared for any form of cross-section," the writer should, it seems, have explained more fully. The tables meant were such as Crandall's or Allen's, giving volumes of triangular prismoids by mean areas formula, and prismoidal corrections for the same. By using these, mean areas volumes or exact volumes may be found as desired. These tables are applicable to irregular work by subdividing the sections. Mr. Gillette also subdivides the sections, but loses part of the advantages of tables if he employs his correction formula instead of the ordinary one. All that was said about tables in the previous communication as to speed, accuracy and necessity for plotting is still claimed to be true. If plotting has to be done for other reasons, as suggested by Mr. Gillette, the plotted sections may be used for convenience, but they are not indispensable. Wellington's Diagrams may be used in a similar way on irregular work. Yours truly.

Granville, O., March 9, 1901. W. H. Boughton.

Franchises for Electric Railways on Country Roads.

Sir: I believe that such franchises as your correspondent, Mr. Kirk, suggests (Eng. News, Feb. 28, p. 153), would not be salable, yet their value largely depends upon the physical character of the country over which it extends, and the population and commercial importance of the cities along the line.

In a rough or rolling country where the railway is compelled to follow the grade of the highway a big item of expense must be allowed for coal bills and breakage of machinery.

It is not the farmer nor yet the merchant to whom the electric railways look for the most support and patronage, but it is the pleasure seeker. A right of way along a public highway, subject to the dust of every passing team, and the constant expense of repairs upon the public road, added to other disadvantages, would, it seems to me, have a depressing effect upon the salability of such a franchise.

Yours truly, W. C. Statler.

Mansfield, O., March 4, 1901.

Sir: I am much obliged to you for inserting the notice of my proposed Pennsylvania road law (Eng. News, Feb. 28, p. 154), in which you ask a very important question: "Would such franchises as our correspondent suggests, be salable." This is a question to which I have given a great deal of attention, and on which I have consulted with the best practical engineers. They all agree that if such roads are made 60 ft. wide and not steeper than 3% grade and the trolley lines are not required to pay any rent during the first three years, but the total rent is to be divided into 17 annual payments, there will be no doubt the franchises will sell at a big margin above cost. Section 30 provides that no rent shall be collected during the first three years of the lease, so as to give the lessee a chance to get into operation. Farther, Section 31 says: "It shall be the duty of the State Chief Engineer to, as soon as possible, secure universal free postal delivery of all mail matter over the state of Pennsylvania." This will be a source of revenue to the trolley line at the start.

In making the above-described 60-ft. highways, it is believed that large beds of valuable minerals will be discovered. There is no doubt that the Ligonier bluestone extends over thousands of acres; and as that is considered the best road metal we have in the United States, there will be a great business ready for the trolley lines to move crushed Ligonier to ballast the trolley line roads, and after that is done there will be thousands of tons needed to keep country roads in order. In view of all the above, I feel confident that the lease of the highways will sell at a premium above their cost.

Yours respectfully, Arthur Kirk.

Pittsburg, Pa., March 8, 1901.

The Cassel Self-Governing Impulse Water-Wheel.

Sir: I have read with interest in your issue of Dec. 27 an article on a "Self-Governing Impulse Water-Wheel" invented by Mr. Cassel. Permit me as a critic to review and comment on the wheel and governor. I am particularly interested in the matter, as the subject of water-wheels has absorbed much of my serious thought for the last two years in connection with the Snoqualmie Falls

Power Co., whose plant was described and illustrated in your issue of Dec. 13, 1900.

It appears on the face of it as though a good water-wheel were sacrificed in order to make a poor governor. It is presumed that at one sweep this new design is to replace the highest types of wheels and governors which are the evolution of years of constant thought, experiment and practice of a noted array of Swiss and American engineers. Permit me to state briefly why in my opinion the new model fails in being a good wheel:

1. The greatest weakness in any impulse wheel is the centrifugal effort of the buckets to fly off. Mr. Cassel has split his buckets and each half bucket becomes an individual bucket with the stream glancing on the side of it. There is a constant effort of the stream to twist the bucket from the rim and the design allows no provision for flanging the bucket in order to straddle the rim and so admit of bolting on.

2. Being a one-sided bucket with the stream striking on the side, there is the constant effort to wrench the wheel itself out of the true plane in which it should revolve perpendicular to the shaft. In a practical working plant this will undoubtedly rack the wheel in time and it will not run true. One of the first points in water-wheel construction, and one of the most difficult to achieve, is to have the wheel run absolutely true to the stream center and to maintain this condition.

3. The design of the buckets is such that the stream will to a large extent reverse itself upon the wheel itself, striking upon the back of the succeeding buckets and thus destroying the efficiency of the wheel.

4. The design of the housing is not ample enough to discharge the water. Our experience here leads me to attach great weight to this criticism. The Cassel design of housing will mean that the stream will follow the buckets, going round with the wheel, filling the housing and cutting into the stream again. This drowning lowers efficiency.

5. As a whole it is complicated, has more working joints, is mechanically weak, and is more expensive.

6. Because of not being rigidly set upon the shaft the wheel will not remain in true precision under practical work, but will slide out of position with respect to the stream either one way or another along the shaft.

Permit me also briefly to state my reasons why the governor as a governor is not an improvement upon common practice and in fact under high heads and heavy loads in a practical working plant will not work out its purpose at all. As a model or a toy the Cassel wheel is interesting, but practical hard experience will justify the following criticisms of the governor:

1. Particular attention is called to the fact that Cassel's is a self-governing wheel. This is true of governing in general, except that Cassel places his mechanism within the wheel, subjecting it to the disturbing and destructive action of the water, while other governors are placed without the wheel, where they can be cared for, protected and lubricated. In both cases the wheel itself actuates the governor and the two are essentially one machine.

2. When the wheel is closed the stream is split by the dividing wedges. The action of the stream is directed to keep the wheel closed, due to the splitting wedges which cut into the jet in such a manner as to draw the two half wheels together. The effort of the governor to separate the half wheels at this point must be enormous, whereas the effort of the governor to further separate the half wheels grows less and less as they separate. In other words, there is a variable condition of stress existing which sets up an uncertain and inconstant element in the regulation.

3. The wheel must not be too loose on the shaft, nor can it be set too tight on the shaft in order for the Cassel governor to work. This introduces the element of friction on the shaft and this element is a variable quantity. With the buckets closed and the full stream on the wheel the pressure on the shaft is much greater than when the wheel is open so that the frictional conditions are variable accordingly. Because of the two foregoing reasons the governor mechanism is never in balance, a situation opposed to elastic operation and sensitive regulation.

4. These variable conditions cannot help but set up "hunting," which is a very objectionable feature when it enters into the speed regulation. With an outside governor of the relay type, such as for instance the Lombard governor, this disorder does not exist.

5. The power of the wheel is transmitted through the governing mechanism, the most sensitive feature of its construction. This is an absurd theory to build upon. It would be quite as reasonable to build a steam engine on the same principle and have the effort of the steam transmitted through the governing mechanism to the driving pulleys.

6. Being in contact with the water at all times and housed up out of the reach of the attendant, the governing mechanism will be subjected not only to the rusting action of the water, but to the erosive effect, which in water of a gritty nature would very soon destroy the whole affair and would at least destroy the sensitiveness of it. I have visited many plants where this erosive action wears the buckets out continually. It adds a new complication where, in addition to the wheel being worn out, the governing apparatus itself must suffer.

Is there any difference in taking the wheel off the stream, as Mr. Cassel does, or taking the stream off the wheel, as the modern wheelmakers do? The conditions are similar. However, is it not better to manipulate the simplest part of your apparatus; that is, the nozzle and stream itself, rather than the most vital and complicated, the wheel revolving with the shaft? I am of the opinion that Cassel's features introduce unnecessary complex problems.

We have succeeded at Snoqualmie Falls in obtaining regulation on the 2,500-HP. water-wheel sets within 1%. The wheels themselves are ponderous affairs, keyed solidly upon powerful shafts, and the buckets are bolted through and through on the solid rims. We have had to take every precaution to maintain the wheel in a central position to the stream center and to keep the buckets on the wheel. Our governor is outside of the wheel housing, entirely free from all disturbing and destroying influences. It is actuated directly by the shaft to which the wheels are keyed. It acts directly and instantaneously upon the valves. It responds simultaneously with the varying changes of load and the speed is maintained constant. It is under the eyes of the attendant where it may be cared for and lubricated. It is as fine a piece of apparatus as a Swiss watch and has almost human intelligence. No mechanical regulator can be perfect because it lacks this human intelligence and the faculty of foreseeing the change of load in advance. In any governor the load must actually change for the governor to act, and no governor except a human being can anticipate a change of load.

Charles H. Baker,
President Snoqualmie Falls Power Co.

Seattle, Wash., Jan. 19, 1901.

The Relative Merits of Garbage Cremation and Reduction.

Sir: I note the use of my letter in your issue of Feb. 14 and I am pleased to have in a small way contributed to your editorial on garbage disposal. I send you a copy of the report of the Department of Health of Chicago for 1897-8. On page 27 of the report I think you will find the scientific data, the lack of which you lament in your editorial.

You very wisely refer to the ease with which investors are attracted to the various plans for reduction of garbage, and the equally attractive story of the promoter of furnaces that will burn ashes, garbage and everything with which they are fed. You rightly infer that the finishing argument that cannot well be withstood is the easy hope that is held out of receiving a bonus from cities. Vast amounts have been sunk in various schemes, yet a fresh crop of investors come to the front at regular intervals.

The Engineering News has frequently referred in its columns to the plant for burning garbage, and securing the value of the heat units, in operation at Shoreditch, one of the vestries of London, Eng. An impression seems to have grown somehow in the minds of many Americans that the value received in electric light pays all the cost of burning. Mr. H. E. Kershaw, J. P., Mayor of Shoreditch, has kindly placed in my hands an abstract of accounts of the Shoreditch plant for the year ended March 25, 1900, from which Mr. E. Allen Frost, Deputy Comptroller of Chicago, has given me the following analysis, under date of Feb 4, 1901:

Sir: Referring to your letter of the 31st ult., enclosing a report from the Shoreditch Dust Destruction Plant, and stating that it has been frequently reported that this plant burns up the garbage of the vestry of Shoreditch, and that the combustion furnishes power for the electric lighting plant, and requesting me to examine the statement and advise you briefly as to the effect of the same, you are respectfully advised that I have carefully examined the statement submitted and find—

That the erection of the dust destructor cost, up to March 25, 1900, $118,945.

Operation for the year ended March 25, 1900: Total cost of operation and maintenance....		$29,155
Receipts for year ended March 25, 1900: For destruction of trade refuse and cash sales	$860	
For steam provided public baths and public library.....	4,675	
		$5,536
This makes a total cost over income.....		$23,620

From the above it is quite evident that the dust destructor does not pay operation and maintenance expenses, to say nothing of interest on the capital invested.

I might say that the statement furnished me shows a loss less than $23,620 by charging the scavenging department approximately $12,500 for destroying refuse. This is not a proper item of income, however, when considering the question as to whether the dust destructor is self-supporting. The above statement seems to answer so far as this particular plant is concerned pretty strongly in the negative the proposition that the Shoreditch Garbage Destructor pays for itself and interest on the money invested in the heat units developed from the garbage destruction. The original papers are herewith returned you.

In 1898 the Chas. Turner Co., of this city, erected a building for the reduction of garbage as a business investment, at a cost, it is claimed, of less than $50,000. It is further claimed that it could be duplicated at the present time very much cheaper. The capacity is 100 tons of garbage a day.

During the year 1900 Mr. Turner claims that his company treated at this plant 10,698 tons of garbage received from private scavengers, and extracted from it commercial products to the gross value of $29,424. He invites inspection, but does not claim to have made any money, as he has been unable to get but an average of about 35 tons a day, but has paid all expenses and has a small margin left towards interest on the investment. He adds, however, that if he could receive 100 tons of garbage a day the plant would yield a handsome profit upon the investment. The company claims it has no patents, but simply submits the garbage to the rendering tanks, extracting grease of a low grade and a residuum that has a market value from which to manufacture a fertilizer.

As shown on page 30 of the Report of the Department of Health, 1897-8, the amount of garbage produced in Chicago is about 425 tons per day, which, according to the figures of Mr. Turner, would make the value of the total daily garbage output of Chicago $1,141, and the value for one year $416,000. Whatever the value may actually be, it is plain that it must be included in computing the cost of final disposal by cremation.

I am not yet advised as to the character of the garbage or the quantity destroyed by the Shoreditch plant. We must bear in mind, however, that it cost $118,945, and that for one year there was a deficit of $23,620 in its operation. A comparison, however, between these two plants, one giving us the example of the utility of burning and the other fairly representing the utility of reduction, will doubtless furnish the reason why most municipalities in the country prefer the reduction process to the process of cremation to which you refer in your editorial, and will also explain, at least in a measure, the reason why it is difficult to get at the figures of the cost of reduction while the plants are owned by private individuals.

Very truly yours, Arthur R. Reynolds, M.D.,
Commissioner of Health.

Chicago, Ill., Feb. 23, 1901.

(It seems to us that the figures given by Dr. Reynolds, in the official report mentioned at the opening of his letter, illustrate the very lack of scientific data which we deplored. He introduces these figures by calling attention to "the wide disparity in the quantities and in the commercial values of the utilizable products of the various reduction processes in different localities." Then, after basing an estimate of the per capita garbage production in Chicago on an everage of records for the year 1895 in a few other cities, he shows that the gross value of grease and tankage for one year in Chicago would be $281,100 by the least productive process, $504,710 by the most productive, and $392,905 by an average of all processes. He then says he "was unable to obtain any authentic data of the relative cost of operating the various plants in the cities visited." The figures used in the calculations appear to have been taken from the report by the late Col Geo. E. Waring, Jr., and others, on "The Final Disposition of the Wastes of New York," abstracted in our issue of Feb. 20, 1896.

As to the fuel value of garbage, we have repeatedly urged that there was danger of overestimating it. (See for example our issue of Aug 26, 1897.)

In our issue of Jan 26, 1899, we published an abstract, with editorial comment, on the first year's operation of the Shoreditch combined refuse destructor and electric lighting plant. The operations for that year, like those for the second year, given in Dr. Reynold's letter, were reported in a very unsatisfactory manner, no credit being given, in either case, to the steam from the destructor boiler supplied to the electric lighting plant, although there is a credit for steam supplied to the public baths and library. The facts seem to be that the Shoreditch vestry prefers to consider the financial results from the joint refuse burning and electric light undertaking, instead of presenting each enterprise separately.

Regarding the operations of the Turner reduction process in Chicago, the figures put forward, like those for the Wright crematory in our issue of Feb. 14, cannot be considered as anything like "scientific data," since both are the claims of private parties for a commercial enterprise, without verification of any sort from disinterested parties; besides which they are only partial figures at best.—Ed.)

Analysis of Pressure on Foundations of Buildings.

Sir: I note in your issue of Jan. 10 a solution given for determining the intensities of pressures on the footing course of a building wall where the footing has an eccentric loading. This and similar cases often arise in practice and present no especial difficulty in solving. In the solution of nearly all engineering problems, assumptions must be made, and those set forth by your correspondent are the ones commonly made in a problem of this nature, namely, that the intensity of pressure varies uniformly from one side of the base to the other, and that the load is concentrated at the center of gravity of the base of the

wall. The following solution is offered, as it may be of interest to your correspondent. Nothing new is claimed for it, as it is similar to the case of a short strut carrying an eccentric load, which may be found in some text-books on mechanics, except that the formulas may be in more useful shape.

Let us assume in Fig. 1, that the wall has a thickness of one unit normal to the plane of the paper, and that the load W is transferred in its line of action to the base at Q; further, that two equal and opposite vertical forces, W, are applied at the center of gravity, or middle of the

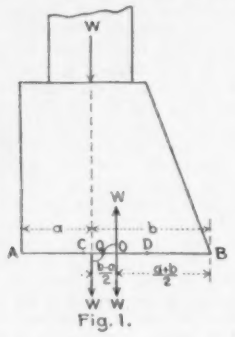


Fig. 1.

Fig. 2.

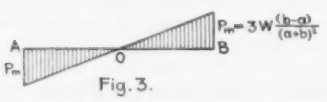


Fig. 3.

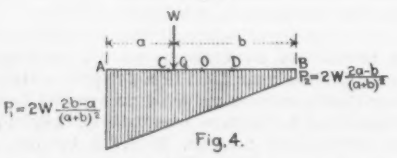


Fig. 4.

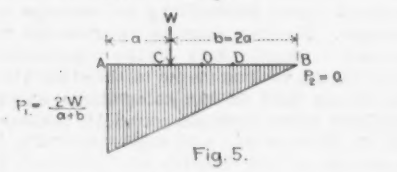


Fig. 5.

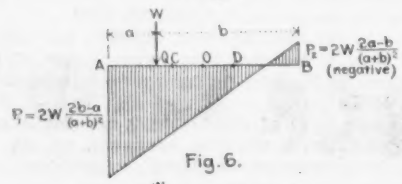


Fig. 6.

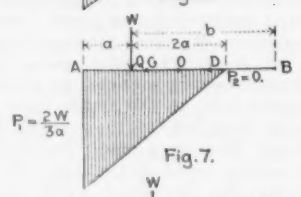


Fig. 7.

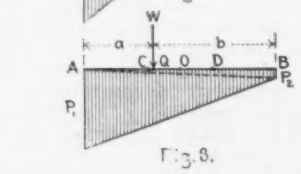


Fig. 8.

base, O. The base A B must then resist the vertical load W applied at O, and the couple whose moment is

$$W\left[\frac{b-a}{2}\right].$$

The first produces a uniform stress over the whole base, whose intensity, Fig. 2, is

$$P_w = \frac{W}{a+b}. \qquad (1)$$

The couple produces a stress varying uniformly from a tension P_m at B to an equal amount of compression P_m at A. Its intensity may be found from the formula:

$$P_m = \frac{M z}{I}. \qquad (2)$$

in which

P_m = the intensity of the stress at A or B;

$M = W\left[\frac{b-a}{2}\right]$ = the bending moment or moment of the couple;

$z = OA = \frac{a+b}{2}$ = the distance from the center of gravity O to the edge of the base at A or B;

$I = \frac{1}{12}(a+b)^3$ = the moment of inertia of the cross-section of the base about an axis passing through O, normal to the plane of the paper.

Inserting these values in formula (2)

$$P_m = W\left[\frac{b-a}{2}\right]\left[\frac{a+b}{2}\right]\left[\frac{12}{(a+b)^3}\right]$$

$$= 3W\left[\frac{b-a}{(a+b)^2}\right]. \qquad (3)$$

See Fig. 3.

The total stress P_1 at A, Fig. 4, then becomes

$$P_1 = P_w + P_m = \frac{W}{a+b} + 3W\left[\frac{b-a}{(a+b)^2}\right],$$

or

$$P_1 = 2W\left[\frac{2b-a}{(a+b)^2}\right]. \qquad (4)$$

and at B

$$P_2 = P_w - P_m = \frac{W}{a+b} - 3W\left[\frac{b-a}{(a+b)^2}\right],$$

or

$$P_2 = 2W\left[\frac{2a-b}{(a+b)^2}\right]. \qquad (5)$$

In Fig. 1 the load W is shown inside the middle third point C, in which case the stresses are as shown in Fig. 4, all compression.

If W is applied at the middle third point C, $b = 2a$, and

$$P_1 = \frac{2W}{a+b}, \qquad (6)$$

$$P_2 = 0,$$

and the stresses will be as shown in Fig. 5; or, in other words, the intensity of the stress at the edge of the base nearest the load is twice what it would be if the load were applied at the middle of the base, and the stress at the other edge becomes zero.

If W is applied outside the middle third point, or $b > 2a$, P_2, formula (5), will become negative and will indicate the amount of tension at B, Fig. 6. However, in this case there can be no tension between the base and the supporting ground, or in a masonry wall it is common to assume that the masonry can stand no tension, then it is assumed that the load is carried on part of the base for a length 3 a, Fig. 7. The stresses would be computed with the load applied at the middle third point of this length, 3 a, Fig. 7, or

$$P_1 = \frac{2W}{a+2a} = \frac{2W}{3a}, \qquad (7)$$

$$P_2 = 0.$$

If your correspondent will reduce his value of x to its lowest terms by factoring out $(a+b)^2$ from the numerator and denominator, he will obtain a simpler expression, namely formula (5) above. And if he will go still further and find the value of $x+y$, instead of y, which he really wants, he will obtain formula (4) above.

A still simpler solution for the specific case he cites would be for him to take his moment axis at A instead of Q, Fig. 8. In this case

$$W = \frac{P_1 + P_2}{2}(a+b). \qquad (8)$$

and

$$W a = \frac{P_1}{6}(a+b)^2 + \frac{2P_2}{6}(a+b)^2. \qquad (9)$$

and inserting in formula (8) the value of

$$\frac{P_1}{2}(a+b)$$

from formula (8), with a simple reduction

$$P_2 = 2W\left[\frac{2a-b}{(a+b)^2}\right],$$

as found above. The value of P_1 could then have been found from formula (8).

In all the above the weight of the footing is neglected, which in most cases would be allowable, but should it be desired to include this, the center of gravity of the weight of the wall and of the footing could be found, and the pressures then determined from this resultant. Or the pressures due to the wall and the footing could be determined separately, and the resulting pressures obtained by algebraic addition.

If your correspondent will look up in his "Trautwine," page 231a, he will find a simple discussion of the distribution of pressure on the base of a masonry dam, which I think he will find no trouble in applying to the case he cites.

Formula (2) is general in its application for determining the stresses on the base of a footing, which has any cross-section, as trapezoidal; for example: M would still be the moment of the couple; P_m would be the intensity of the stress at the edge distant z from the center of gravity of the base; and I would be the moment of inertia of the cross-section of the base taken about an axis passing through the center of gravity of the base, and normal to the plane of the paper. In formula (1) the area of the cross-section of the base would be taken instead of $(a+b)$, and W would be the weight supported by the cross-section of the base.

Formulas (4) and (5) are applicable only to the case in which the cross-section of the base is a rectangle.

Yours truly, John H. Gregory,
Assistant Engineer, Improvement of Water Supply.
710 City Hall, Philadelphia, Pa., Jan. 19, 1901.

Sir: With reference to the letter of Mr. Kemmler in your issue of Jan. 10, there seems room for a difference of opinion, so that a discussion may be profitable. The references quoted by you do not deal with the precise point which is the maximum pressure caused by eccentric loading. Within a limit to be mentioned hereafter the maximum unit pressure can be obtained by the usual method for a combined direct and bending stress. Let N, Fig. 1, be the neutral axis of a foundation area; P_1 the resultant load; n its eccentricity; y the distance of the

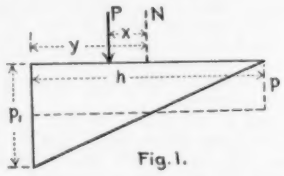


Fig. 1.

fiber in question from the neutral axis; h_1 the width; p the unit stress from uniform distribution of load, and p_1 the maximum stress; M and I the usual symbols.

$$\text{Then } p_1 = p \pm \frac{M y}{I}.$$

We have $p = \frac{P}{h}$ and $M = P x$, and as we are generally concerned with a rectangle of length unity we may write $\frac{h^3}{12}$ for I. Take Mr. Kemmler's first case, where P falls at the middle third and we have,

$$p_1 = p \pm \frac{P \times h \times 12}{6 \times 2 \times h^3} = p \pm \frac{P}{h},$$

which is o or 2 p, as is well known. Here, I cannot follow Mr. Kemmler, as if by W he means the unit stress, the maximum stress is certainly not ⅔ W, and if W means the load, how can the maximum stress be a definite fraction of it without reference to h?

Since we cannot, except under very peculiar circumstances, have tension on a foundation, the above method fails where it produces a negative result, which is the

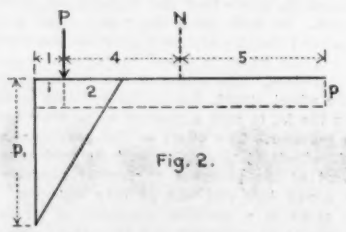


Fig. 2.

case where the line of pressure falls outside the middle third. As engineers have no use for such foundations, the formula covers all practical cases, but the geometry of the problem gives us a solution, if required, for an extreme case. Let us take Mr. Kemmler's second case, where P falls 1-10th of the width from the edge as in Fig. 2. We know that the envelope of the unit stresses must be a triangle, that P will pass through its center of gravity and that the area of the triangle must equal that of the rectangle ph. The base of the triangle will then be 3 and

$$\tfrac{1}{2} \times 3 \times p_1 = 10\ p \text{ or } p_1 = 6.6\ p.$$

The first treatment is given in many engineering text books, but the second is not, probably because it is not regarded as a practical case. Yours faithfully,

F. E. Robertson,
London, England, Jan. 26, 1901.

Notes and Queries.

In the diagrams accompanying Prof. Hatt's paper on "Slag Cements" in your last issue, the scale of "pounds per square inch" for Fig. 6 was changed by a draftsman's error, giving the numbers on that figure double their true value.

Chas. N., Cohoes, N. Y., writes:

Please inform me which is right, to settle a bet. A bets that the outside of a wheel goes faster than the hub. B bets that they both go at the same gait.

The bets had better be declared off until the bettors can agree on what they mean by the word "go." If they mean motion through the air, then the rim of the wheel goes the faster, having the same total forward motion as the hub and a motion of rotation as well.

EXPANSION IN BRICK PAVEMENTS.

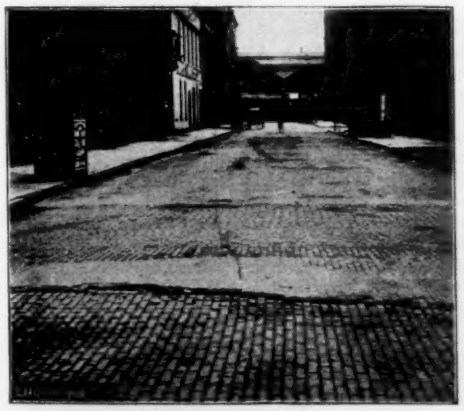
By. Prof. Daniel B. Luten.*

Numerous instances are on record of rumbling sounds produced by brick pavements under traffic, especially during the heat of summer. The noise has usually been attributed to the tendency of a crowned pavement to rise free from the foundation at the center of the street because of the expansion of the brick with increase of temperature. This theory has been objected to by some, on the ground that the curbs of a pavement would hardly have sufficient stability to resist the thrust of so flat an arch, loaded with several tons of dead and live load.

A photograph of some interest in this connection is herewith submitted. The brick pavement on Georgia St., at the corner of McCrea St., in Indianapolis, had been opened for water connections; the repairing of the portion over the trench was done with new brick, the joints being filled with cement grouting. The rest of the pavement, which was not disturbed, had evidently been filled originally with sand filler. The trench lies in line with and extends along the gutter of Georgia St., and lies across the end of McCrea St.

In August, 1900, on an extremely warm day, this narrow strip of cement-grouted pavement was found to have broken away from the rest of the surface, and to have risen from the foundation, so that the arched portion at the center of the street was 2½ ins. above the general surface. The part thus affected was limited in width to about 4 ft. and was quite sharply defined by the cement grouting, all shown in the photograph.

The arched portion of the pavement produced a hollow rumbling sound upon the passage of vehicles, although the noise from the rest of the pavement was the usual dead rattle of a brick pavement. The rupture of the pavement was undoubtedly caused by expansion, due to the increased temperature. The pavement had been forced upwards free from the base, and that, too, over the trench, where pavements usually exhibit quite a different tendency. The lines of rupture could be traced from curb to curb of McCrea St. The arching was probably not caused by expansion of the brick between these curb lines alone; the cement-grouted portion extended indefinitely along the gutter of Georgia St., and that had probably helped to produce the result, although no movement of the brick could be detected. The rise of 2½ ins. seems too great to be attributed to



View of Raised Strip of Brick Pavement, with Cement Grout Filler, Indianapolis, Ind.

expansion in an arch of about 34 ft. span, and 6 ins. rise. Theoretical considerations would seem to show this, as well as to prove that the phenomenon as usually observed is due to expansion.

The coefficient of expansion of paving brick has been determined by experiments made at the Watertown Arsenal to be about 0.0000032 for 1° F. The increase in width of a street 34 ft. wide, if unconfined, would be 0.013 in. for a rise in temperature of 10°. If the pavement has a rise of 6 ins. and the abutments be considered immovable, this increase in width would result in raising the crown about 0.2-in. Assuming the weight of the brick at 40 lbs. per sq. ft., and the coefficient of elasticity at 1,000,000 lbs. per sq. in., a rise of temperature of about 25° F. would be required to overcome the compression of the brick, before lifting the arch free from the foundation. After that time, the rise of the pavement would be very nearly proportional to the increase in temperature, provided the curbs remained immovable, and for a further increase of 50° F. would be about 1 in.

Such a theoretical discussion must of course be more or less unsatisfactory, on account of the indeterminate nature of many of the quantities involved. It may serve to show, however, that expansion of the brick due to summer heat may be responsible for the arching and consequent rumbling, notwithstanding the fact that many engineers consider it impossible and absurd.

As to the ability of the curbs to resist the thrust of so flat an arch, if we assume a pavement width of 34 ft. and rise 6 ins., and weighing 40 lbs. per sq. ft. to be loaded at the middle with six tons distributed over 12 ft., the thrust of the arch would be about 10½ tons for 1 lin. ft. of curb. This thrust the curb would probably be able to resist, especially when backed by stone sidewalks, as is frequently the case.

This peculiarity of cement-grouted brick pavements has frequently been used as an argument against cement grouting and in favor of tar. As the former is much the cheaper, and also the more durable, this argument is unfortunate, especially as an expansion joint at the curb is an effectual preventive of the arching in question. In laying a brick pavement, a ½-in. board should be set against the curb, and the brick laid abutting against this board; after the courses are completed, the board is removed, leaving a ½-in. space between the brick and the curb, which may be filled with sand. The danger of water penetrating through this joint to the injury of the foundation amounts to nothing. The cost of the pavement is not increased by this precaution, nor is its durability endangered.

*Temporarily at Los Angeles, Cal.

TYPHOID FEVER IN U. S. MILITARY CAMPS DURING THE SPANISH-AMERICAN WAR OF 1898.

A report with the title given above has been published recently by the Surgeon General of the U. S. Army. It was the work of Majors Walter Reed, V. C. Vaughan and E. O. Shakespeare, Surgeons U. S. Army, the last two in the Volunteer service. A brief notice of the report is given under New Publications, in the Supplement to this issue. What follows has been abstracted from the report:

During the Spanish War of 1898, every regiment constituting the first to seventh army corps, save the sixth, developed typhoid fever, regardless of whether they were volunteers or regulars Of 106 regiments, 33% reached camp with recognized cases of typhoid, and within eight weeks the disease was in nearly every regiment. Large and small encampments, whether located in the North or South, developed epidemics of the disease. The spread of the disease was due very largely to camp pollution, the number of cases, in a general way, varying in the different camps, with the methods of disposing of the excretions. Where the water carriage system of disposition cannot be employed, the report states that "all fecal matter should be disinfected and then carried away from the camp." Although the commission concluded that "infected water was not an important factor in the spread of typhoid" in the camps, it wisely recommends that "troops in the field should be provided with means for the sterilization of water." Among the factors in the dissemination of the disease flies "undoubtedly," the persons and clothing of the men "more than likely" are to be included, while it is "probable" that air-borne dust was involved "to some extent."

On careful study, the records show that of 107,973 officers and men in 92 regiments, the number of cases of typhoid fever was probably 20,738, or 19.26% of the total, but of these only 10,428, or 50.27%, were so diagnosed by regimental or hospital surgeons. The corrections made by the commission are based on close examinations of all available records, and on information secured by tracing the patients to civil hospitals. Of the 20,738 cases 1,580, or 7.61%, died, which corresponds closely with the mortality shown by careful records in civil life. The deaths from typhoid fever were 86.24% of the deaths from all causes, the mortality from this one disease being at the rate of 14.64 per 1,000 men.

A NEW SCRAPING TOOL FOR DRESSING STONE.

The accompanying sketch and half-tone view illustrate the construction and mode of operation of a new scraping tool for dressing limestone, sandstone, and similar soft building stones. The construction and method of using this tool and the advantages claimed for it are described as follows by Mr. James N. Hatch, the inventor:

The use of the stone-scraper for giving a tooled surface to sandstone or limestone is an economical method

Fig. 1.—Details of Scraping Tool for Dressing Stone.

of accomplishing very satisfactory results. Where large surfaces are to be given this style of finish the scraper is a great labor saver. A much more even and uniform surface can be obtained in this way than by means of the ordinary hand tool. Any good, intelligent laborer, after a few hours' practice, can, with this machine, do better work and more work than an old experienced stone-cutter can by the old method.

The scraper, as shown by Fig. 1, is made of 1⅛-in. round iron, bent into a reverse curve. A piece of 1-in. round iron is welded onto one end to form a handle and the other end is flattened to receive the bit. A bolt pass-

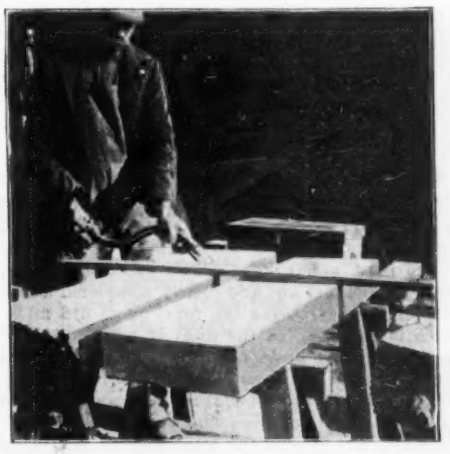


Fig. 2.—View Illustrating Method of Using Scraping Tool in Dressing Stone.

ing through a hole in this flattened portion and a corresponding hole in the bit holds the bit in place. When a bit gets dull it is easily replaced by a sharp one by simply loosening the nut which allows the bit to drop off and the sharp one to be substituted. To use the tool two stones are placed side by side, as shown by Fig. 2, and a straight edge weighted with two heavy spalls to hold it in place is placed across them. The scraper is held up against the side of this straight edge and pushed across the stone again and again until the required finish is obtained. A man working eight hours per day can, with good average limestone, tool from 30 to 40 sq. ft. of surface.

FLOW IN THE SEWERS OF THE NORTH METROPOLITAN SEWERAGE SYSTEM OF MASSACHUSETTS.

A paper with the above title was read by Mr. Theo. Horton, Assoc. M. Am. Soc. C. E., before the American Society of Civil Engineers on March 6. The paper described three series of current meter readings taken in July, 1896, December, 1897, and June, 1900, below the Charlestown and also below the East Boston pumping stations. A four-vane Ellis meter was used. The paper gave no particulars as to the area or population contributing to the flow of sewage, being designed to show merely the results of the current meter readings and the deterioration of the carrying capacity of the sewer.

The sewers had been in use about ten months when the first readings were taken. A table was

presented showing for each reading the depth and mean velocity of flow, the quantity in cubic feet per second, the hydraulic mean radius, the values of C and n. The observed flows ranged from 6.1 to 138 cu. ft. per sec. The average values of n, as used in the Kutter formula, are given for the Charlestown sewer as 0.0131 in 1896; 0.0148 in 1897; and 0.0152 in 1900. In the East Boston channel the corresponding values were 0.0117, 0.0127 and 0.0133, respectively. The Charlestown sewer is 6 × 6⅝ ft. in cross-section, of basket handle shape, with a hydraulic grade of 1 in 2,000. The East Boston sewer is 9 ft. in diameter, with a hydraulic grade of 1 in 3,000. Both sewers are of brick, cement-washed.

In July, 1896, after the sewers had been in operation about ten months, the masonry appeared to be "in almost its original condition." Above and below the water line there was a "thin coating of grease of a leaden color," and some organic growth. In December, 1897, the growth was not much heavier, but covered a greater area; besides which there were "slight incrustations at frequent intervals, due to barely visible seepage of ground water." In June, 1900, the condition of the sewers was not much different than in December, 1897, except that the incrustation seemed to be slightly greater.

The discussion on the paper was opened by Mr. Rudolph Hering, M. Am. Soc. C. E., who, after asking the author a number of questions, seemed to be satisfied with the results shown by the paper. Mr. Hering cited an instance of organic growth in some pipe sewers in a western city, which badly clogged the sewers. Mr. Geo. W. Tillson, M. Am. Soc. C. E., told of a somewhat similar experience with the early sewers of Omaha, built on the separate plan, without manholes, and with inadequate flushing. Mr. J. Waldo Smith, M. Am. Soc. C. E., said it was gratifying to see how these observations on deterioration of the inner surface of large sewers corresponded with experiences with large water conduits.

STATE ROAD CONSTRUCTION IN MASSACHUSETTS.

The report of the Massachusetts State Highway Commission for the year 1900 shows that since its organization in 1893 it has built 296 miles of improved road, about 46 of which was completed in 1900. Roads laid out and nearly completed at the close of the year bring the total up to 316 miles, which is only 24% of the total of 1,334 miles for which petitions have been filed. The petitions came from 274 towns and 25 cities. From 1894 to 1900, inclusive, the legislature has appropriated $3,500,000 for the construction and repair of State highways, but 25% of the total cost of new roads is borne by the counties in which the roads are located. Beginning with the year 1900, the cost of repairs, up to $50 per mile per year, is assessed upon the several towns; also beginning with the same year the salaries of the commissioners, the engineers, clerks and assistants in their office, and traveling and office expenses, amounting to $29,500 in all, were met by a special appropriation, outside the $500,000 for construction and repairs.

As to the depth of stone employed in road construction the commission says:

> The commission has estimated that non-porous soils, drained of ground water, at their worst, will support a load of about 4 lbs. per sq. in.; and, having in mind these figures, the thickness of the broken stone has been adjusted to the traffic. On a road built of fragments of broken stone, the downward pressure takes a line at an angle of 45° from the horizontal, and is distributed over an area equal to the square of twice the depth of the broken stone. If a division of the load, in pounds, at any one point, by the square of twice the depth of the stone, gives a quotient of four or less, then will the road foundation be safe at all seasons of the year. On sand or gravel the pressure may safely be placed at 20 lbs. per sq. in.
>
> Acting on this theory, the thickness of stone on State roads varies from 4 to 16 ins., the lesser thickness being placed over good gravel or sand, the greater over heavy clay and varying thicknesses on other soils. In cases where the surfacing exceeds 6 ins. in depth, the excess may be broken stone, stony gravel or ledge stone, the material used depending entirely upon the cost, either being equally effective.

Good road building gravel is comparatively scarce in Massachusetts. Where employed it has been used as it came from the bank, or has been screened, or in some instances it has been crushed and screened and then laid like macadam. Mr. Chas. Mills, Chief Engineer of the commission, says:

> The screened gravel roads are easily maintained, but wear rapidly, and, as the cost of resurfacing is nearly as great as the cost of resurfacing a macadam road, it does not seem to be economy to continue their construction, except in localities where stony gravel is abundant and broken stone available only at great expense.

Some interesting experimental road work at Truro, in which stone and clay were tried, is described as follows in the report:

> Three years ago an experimental road was built in Truro. This road was of rounded beach stone and clay. It has shown good wearing qualities, but, owing to the shape and size of the stone used, its cost was greater than would result from substituting broken stone for the gravel.
>
> The experimental mile of road built two years ago in Truro has proved a success, and is well worth a description. The sub-grade is loose sand. There is practically no surface loam on the land adjacent to the road. The drainage is perfect. There is not much snow or frost during winters, and the traffic is small in volume and light. The sub-grade was shaped to the grade and cross-section desired, and on this was spread clay, naturally sandy, containing 1 part of sand to 2 parts of clay, to a depth of 2 ins.; over this was spread a layer of broken stone 3 ins. in depth, the fragments varying in sizes from ½ to 1½-ins. in diameter. The broken stone was then covered with a layer of clay 1 in. in depth. A long-toothed spike harrow was then dragged back and forth until the clay and broken stone were well mixed, and then the entire surface was watered and rolled with a two-ton horse roller. An occasional sprinkling of sand, since its completion, has prevented the clay from becoming muddy, and the surface is reasonably smooth and free from loose stone.

The average cost of a standard mile of road in Massachusetts was $8,957 for macadam, and $7,074 for gravel, during 1900. By a standard mile is meant one with a stone or gravel roadway 15 ft. wide, with shoulders 3 ft. wide "shaped to the same cross-section as the broken stone." It should be noted that these figures include painted guard rails at steep embankments; also culverts of vitrified or iron pipe, or of masonry, where there is a large volume of water. The commission says that "there are several reasons why the average cost of State roads in Massachusetts is greater than it is in other States." The first one to be cited is the selection, for early construction, of "the most difficult sections on long petitioned lines." Another reason is the legislative nine-hour day in Massachusetts, against ten hours in New Jersey, and a 20% excess in the cost of labor and teams. In New Jersey (we may add), culverts and bridges over permanent streams are provided at county expense, at least in the eastern part of the State; while guard rails are not usually erected on the State road work.

Repairs to stone roads, the Massachusetts commission says,

> should begin the day they are opened to traffic, and the attention which they receive the first few months of use determines their usefulness and length of life."

Accordingly the commission has adopted the system of continuous repairs, the cost of which "is about equally distributed over the roadway and roadside." Where the length of road warrants it, the work is done by men who devote their whole time to it. Otherwise, it is done by local men, under a division engineer, which proves much more costly than the first-named plan. Thorough rolling with a steam roller as soon as the frost is out in the spring, and before the subgrade is dry, "is one of the best means of keeping a stone road in good condition." The report contains a table showing the cost of maintaining roads by towns prior to 1900, in 1900, and the total to the close of that year, with the average per mile, both total and for 1900. The maximum expenditure for maintenance was $660.68 per mile per year for 1.61 miles of road in Athol, or a total of $4,254 since the road was built. The expenditure per mile in 1900, for this stretch, was $103.38. Considering the year 1900, alone, the repairs per mile of road ranged from $0.96 for 2.08 miles in Haverhill, to $1,125 for 4.19 miles in Leicester. The Haverhill road had no expenditure for repairs prior to 1900, and presumably was new. Repairs on the Leicester road, since its construction, have cost an average of $660.25 per mile per year, or within 43 cts. of the figure already given for Athol. It would be interesting to know the average cost of repairs per mile per year for all the State roads built, and also the average for 1900, but the computation would involve much labor.

The report made to the commission by Mr. Mills contains some interesting figures on the cost of painting guard rails and on the "changes in cross-section" of macadam roads, as follows:

> During the year 1899 most of the guard rail previously built on all the State roads was repainted. Following is a statement of the average cost per lineal foot, etc.:

Lineal feet of guard rail painted	350,000
Cost of paint, not including freight, per gallon	$1.00
Cost of paint per lineal foot of guard rail	.003
Cost of paint and painting per lineal foot of guard rail	.025
Lineal feet of guard rail painted, per gallon	114
Quantity of paint used per lineal foot, in gallons	.007
Time required for painting, per lineal foot, in hrs.	.020

To ascertain the changes that have taken place in the cross-sections of roads between the time of their completion and approval by the commission and the present time, in December of this year, cross-section notes were taken on 40 sections of State highway in 17 towns in different parts of the State, built each year from 1894 to 1899, inclusive. On these 40 sections of road the elevation in the middle of the road averages 1.03 ins. lower than the original elevation. The crown, which originally averaged 0.57 in. per ft. at present averages 0.47 in. per ft.—a loss of about 30% from the original crown.

The following statement shows the changes in the cross-sections on the different layouts:

Lay-outs.	No. sections of road.	Crown, ins. per ft. Original.	Crown, ins. per ft. Present.
1895	7	0.694	0.500
1896	9	.583	.514
1897	12	.645	.500
1898	7	.625	.500
1899	2	.688	.625

The foregoing figures seem to show that the standard section adopted by the commission, giving a crown of ¾ in. per ft., is not excessive, as the crown of a road is sure to lessen by the effects of travel and weather.

The guard rails are made of shaved cedar posts 8 ft. c. to c., a 4 × 4-in. top rail, 3½ ft. high, and a 2 × 8-in. side rail. Both rails are planed. The rails and exposed portions of the posts are given, when new, "two coats of light-colored paint easily seen at night."

The quotation does not make clear whether the changes in cross-section were determined by comparing the original grade levels with those existing at the time of the observations, or by trenching across the road and measuring the actual thickness of the macadam; in other words, it is uncertain whether the measurements indicate wear alone, or both wear and settlement. Since the foregoing was written we have learned from Mr. Mills that the figures given "were obtained by comparing the present with the original surface levels, using the same bench marks." It is proposed to make further observations this spring, and also to determine the actual thickness of macadam on roads showing the greatest changes.

The members of the commission are as follows: Mr. W. E. McClintock, M. Am. Soc. C. E.; Harold Parker, M. Am. Soc. C. E.; and John H. Manning. Mr. Chas. Mills is chief engineer of the commission.

RECONSTRUCTION OF THE MISSOURI RIVER BRIDGE AT GLASGOW, MO., CHICAGO & ALTON RY.

By W. D. Taylor, M. Am. Soc. C. E.*

The bridge built in 1879, by Gen. Wm. Sooy Smith, M. Am. Soc. C. E., as Chief Engineer, to carry the Chicago & Alton Ry. over the Missouri River at Glasgow, Mo., is shown in Fig. 1 as it was in June, 1899. It was a single-track high bridge, with all spans fixed, and having the track about 50 ft. above high water. It was said to be the first all steel bridge built in America. On the east shore there was 211 ft. of iron viaduct starting from a small abutment on the edge of the Glasgow bluffs. Then came two 138-ft. deck spans, three through spans of 311 ft., and two deck spans of 311 ft. The west approach consisted of one 140-ft. deck span and 508 ft. of iron viaduct, followed by about 91 ft. of wooden pile trestle used to join the iron work to the 45-ft. embankment leading up to the bridge from the west.

The abutment, piers and pedestals of the east approach had fairly good foundations on the sandy clay of the Glasgow bluffs, and had given little trouble. All the rest of the substructure had been, or was, in bad repair.

Piers No. 1 and No. 2 had been rebuilt to a point above high water, the one with Massachusetts granite, and the other with Missouri granite, and the masonry in each case had been surmounted with costly steel towers about 35 ft. high. Piers Nos. 1, 2, 3 and 4 had originally been built of inferior limestone. They were built solid to a point above high water, with the usual ice breaker nosed with iron, and then they forked into two towers, each some 50 ft. high. These towers had been of ornamental construction when first built, but upon the stone's cracking and crumbling under the joint effects of the weather, the yielding foundations, or train vibration, it

*Assistant Engineer, Chicago & Alton Ry., in charge of the reconstruction of the bridge.

had been very early necessary to encase each of the stone towers in a skeleton iron framework throughout the height of the tower. This casing is shown on the top of one of the old towers which appears in the foreground of Fig. 6. These old stone towers were still in place on piers Nos. 3 and 4, though they had been removed when piers Nos. 1 and 2 were rebuilt.

The tops of the towers of piers Nos. 3 and 4 had both been repaired, but in different form. The whole top of both towers of pier No. 3 had been masonry. All the masonry west of this pier was to be rebuilt on pile foundations topped with concrete, which concrete should extend in every case 11 ft. below the surface. Half of the old west approach viaduct and all of the wooden trestle was to be filled in with earth, and a new 45-ft. heavy wing wall abutment backed with concrete and faced with Bedford stone was to be constructed at the west end of the bridge. The old superstructure was to be removed entirely. The old steel superstructure had been built for loads of two 66-ture was removed, by the middle of January, 1900. For a full description of the construction of these caissons and piers the reader is referred to a paper read Feb. 6 before the Western Society of Engineers by Mr. H. P. Boardman, Assistant Engineer, Chicago & Alton Ry.

Probably the most remarkable point about the piers is that, though each one of the caissons came down on bed rock more or less uneven, the cutting edge in each case was brought down, as required by the specifications, to almost a per-

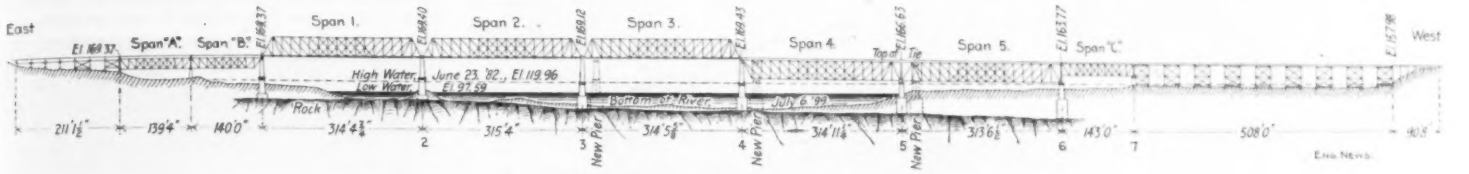


FIG. 1.—MISSOURI RIVER BRIDGE AT GLASGOW, MO.; CHICAGO & ALTON RY.
(Condition in June, 1899; dotted lines indicate the new piers now completed.)

encased in a strong framework of iron and concrete. Both spans resting on pier No. 4 had been jacked up on falsework, the tops of the old towers torn down, and a strong framework of steel about 8 ft. high had been put in, binding the tower tops together.

Pier No. 5 had been jacked up in the same way as No. 4, but the coping and belt course had been renewed with stone of good quality. Pier No. 6 was in very bad condition. The old masonry at the pier top was disintegrated, or shaken to pieces; some of the joints and cracks in belt course and coping being open as much as 2 ins.

Piers Nos. 3, 4, 5 and 6 were founded on pneumatic caissons. All piers from Nos. 1 to 6 were supposed to rest on bed rock. From pier No. 6, west, pier and pedestal had simply been set a few feet down into the soil of river formation and had settled till the grade line of the track above was spoiled. The old steel superstructure, though light, was in good condition, and had never shown any signs of weakness.

It was decided early in 1899 to reconstruct the entire bridge. Several plans of reconstruction were suggested. One was to build an entirely new bridge alongside the old one. Those who advocated this measure wished to avoid all possibility of interference with traffic in rebuilding the bridge. The plan finally adopted, however, utilized all the ton engines followed by a load of 1,820 lbs. per lin. ft. The new superstructure was to be built for loads of two 162½-ton engines followed and preceded by a train load of 5,000 lbs. per lin. ft. The old river spans were Whipple trusses. The new ones were to be of the Pratt type of truss with curved top chords. In the new bridge the three 138-ft. spans were to be lattice girders.

The viaduct on the west side which had consisted of a succession of 30-ft. girders (each alternate girder over a tower) was to be in the new bridge only 230 ft. long, consisting of only two towers with 55-ft. girders between the towers and between tower and pier No. 7 and the abutment. The new east approach viaduct was to be made up by doubling up the girders taken from the west approach, using four girders where two had served before.

The grade line of the old bridge ran level to pier No. 4 from the east approach and then descended with a sharp apex angle over the pier to the west with a grade of 0.9%. The grade of the new bridge runs level from the east approach to pier No. 3. Thence a vertical curve rounds off the break in grade to pier No. 5, the camber rounding out the curve, from which the grade descends to the west on a grade of 0.75%.

Fig. 2 shows three of the river spans of the new bridge in connection with the west approach, and fect level plane, and resting all the way around on bed rock, which was a fine grained good sandstone and was ditched out to receive the cutting edge.

The superstructure was designed throughout by Mr. August Ziesing, M. Am. Soc. C. E., and contracts were let to the Lassig Bridge & Iron Works, of Chicago, for the new steel superstructure and its erection on falsework, which the railway was to furnish and construct.

In January, 1900, the work was suspended till the end of April, when the work of tearing out the old bridge and putting in the new was begun and carried on continuously till the riveting was completed on the approaches on Jan. 15, 1901.

Night crews working by means of an electric light plant were put on during the whole season whenever they could be worked to advantage. There were only two Sundays from June to December when gangs of men were not at work on the bridge, and oftentimes the whole force were at work. There were employed 2 locomotives, a steamboat, 6 barges, 10 hoisting engines, 3 travelers, 2 derrick cars, and (at times) a force of 250 men.

There were no unusual features in the shore work except perhaps in filling in the old viaduct on the west side. There was no falsework used and the dirt was simply dumped around the old

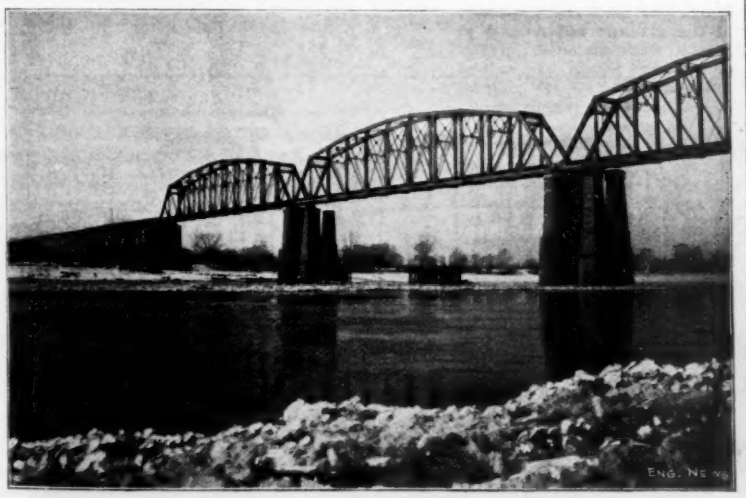


FIG. 2.—WEST END OF THE GLASGOW BRIDGE.

FIG. 3.—EAST END OF THE GLASGOW BRIDGE.

good masonry of the east approach, and piers Nos. 1 and 2 (which had been rebuilt), also pier No. 6, or as much of it as could be used.

It was decided to make the main channel span (Span No. 2) one panel length (28 ft.) longer than the other river spans, and to build entirely new piers just west of piers Nos. 3, 4 and 5. It was decided to make the fourth span a through span also and to shorten up the fifth span by one panel length, thus landing the west end of the fifth span on old pier No. 6, which was to be torn down and rebuilt in order to remove the impaired Fig. 3 shows the remaining river spans in connection with the east approach.

Early in 1899, permission was secured from the Secretary of War to reconstruct the bridge, conditioned upon the keeping open at all times of 150 ft. of clear waterway for river traffic under span No. 2 or No. 3.

Contracts were let in August, 1899, to the Engineering Contract Co. for the building of new piers Nos. 3, 4 and 5. The caissons were sunk for these new piers and the masonry built up as far as was possible till the old steel superstructowers and the girders removed when the earth had got high enough to carry the track. The earth was dumped in October and November and the new earth embankment of Missouri clay has carried the track very satisfactorily so far. As the length of the filled in portion of the viaduct was only about equal to the length of 11 cars, it was uneconomical to plow off the dirt from the cars by pulling the plow along the top of the cars in the more common way. Frames were constructed fastened to the bridge ties so that the plow could be anchored down in one place, and the train

pulled through under the plow, the plow being so located as to dump the dirt symmetrically around the towers. This work was done by contract, and it had been arranged that the contractor should furnish teams to spread the dirt uniformly, in the fear of sidewise settlement of the heavy embankment against the tower legs and bracing. But after a few days trial the contractor was allowed to withdraw his teams, as it was found the work he was doing was unnecessary. Done in this way there was no lateral settlement to speak of, though there was considerable vertical settlement in one place under the weight of the 45-ft. embankment, in which place previous borings had shown that a stratum of quicksand underlay the surface.

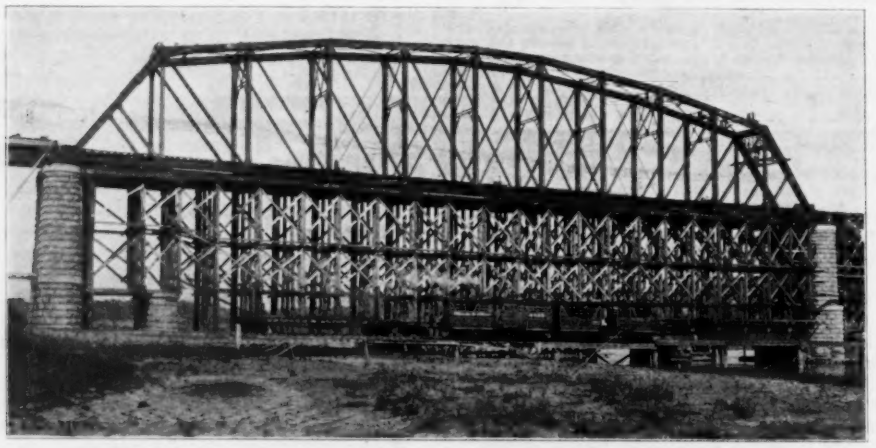


FIG. 4.—FALSEWORK OF SHORE SPAN.
(One end carried by plate girders over scoured portion of channel.)

It might be of interest to note that careful estimates showed that at prices current at the time there was a saving of $17 per lin. ft. in filling this viaduct (45 ft. high) with earth that had to be hauled five miles by train, over the cost of rebuilding the viaduct. Only the fear of too much constriction of the waterway in excessive floods prevented the filling in of the whole west shore viaduct.

Fortunately there was no high water to speak of after June, and some risks of losing falsework having been taken, the late high water season found the work very well advanced. The work proceeded from west to east, so that only one span of the old superstructure needed to be taken down at a time.

The stone for all the piers and the abutment were cut to true dimensions by the Bedford Stone Co., and each stone was checked up by measurement in all three dimensions as it arrived on the cars at Glasgow. The building of the new piers proceeded rapidly when the old steel was removed. One derrick laid four courses of this heavy masonry a day.

Some of the most tedious work was the construction of the falsework under the deck spans where the height was insufficient to handle piles in any of the usual ways. A kind of cagework was constructed enclosing the pile driver leads and this caging was suspended from the old track and swung down through the framework of the deck spans and guyed laterally to the steel work.

The putting in of the additional caissons and piers the fall before, constricting the waterway, had had the effect of causing the river to scour out a narrow deep channel nearer the center of the stream, and also had caused the banks of both shores to move inwards more than 200 ft. Under the west end of the east deck span the deposit of soft muck since the season before was as much as 20 ft. in depth, and under the east end of the same span the bottom had scoured out till there were only two or three feet of silt on bed rock. Both changes gave trouble. It was out of the question to use piles both here and further out in the river in the places scoured out unless they could have been braced by methods which would have been expensive and more or less unsatisfactory.

Under the scoured out portion of this span, cribs were sunk. A double row of plate girder bridges was laid from crib to crib and the falseworks were built on top of the girders. Fig. 4 shows this span with part of the falsework on the girders and the new steel in place on Sept. 21.

Under the two middle through spans in the main current of the river it was never contemplated to use any other plan of constructing the falsework than that of using two Howe trusses under each span, the two trusses resting on three cribs. These trusses were 26 ft. high vertically, 142 ft. long, and weighed 225 tons. Each truss has really four trusses placed side by side, a little more than 8 ft. c. to c. Fig. 6 affords a top view of the Howe truss in place.

The entire top and bottom chord of each truss consisted of 16 pieces of 8 × 16-in. timbers. These trusses were designed specially for this work by Mr. August Ziesing. They were framed on shore and erected in place, the erection being done on a barge where there was not silt enough to hold piles on which to do the erection. Fig. 5 shows span No. 3, after the erection of the new steel for this span was completed.

The construction of the cribs was a comparatively easy matter in most places where they were used. If there was silt enough on the bottom to hold the piles they were driven first; then the crib work was built in place around them, log house fashion, building up as the framework sank. Then the crib work was filled with riprap to steady the piles and the grillage put on.

But in the case of two of the cribs, those on each side of pier No. 3, in the middle of the river, the bottom had scoured out till the bedrock was as clean as a floor 42 ft. below the surface. These cribs were begun in still water, built up some 10 ft. in height, and floated into position where they were anchored laterally to the piers, and both up and down stream to pile clusters. The crib work was then added, building up as the framework sank till it rested on the bottom. The piles were then set in by simply lowering from the bridge above and braced in position till the crib was filled with riprap to steady the piles.

A good deal of trouble was taken with one of the first of these cribs to proportion the bottom of it, so that it would land symmetrically on the bottom. But in the case of those landed on the silt the bottom was found to be of an entirely different contour by the time the crib work reached it, while out in the open river it was found next to impossible to get soundings in the swift current accurate enough to proportion the bottom by. After the first trial it was found that it was possible to so adjust the amount of rock in the pockets as to keep the framework in delicate suspension in the water, and as soon as any part of the crib landed to suspend the crib from some of the framework overhead so as to keep it level while the piles were set in. When the riprap was added the stone would work out under the timbers that were not touching the bottom and fill in the space till the crib was steady. Then some of the riprap was thrown around on the outside of the crib to make sure and the suspending cables were removed. The effort to proportion the bottom of the crib to fit the bottom of the river was only made for one of the eight cribs.

The Howe trusses used to support the river work were expensive and as (under the Government regulations) the two main channel spans, Nos. 2 and 3, could not be blocked by falsework at the same time, only three of the trusses were constructed. Two of the barges which had to be built to do so much of the necessary work were designed to float these 225-ton trusses from one span around to another. Two trusses were built in place under span No. 3 and one under the east end of span No. 2, leaving the west end of span No. 2 open for river traffic. When span No. 3 was sprung, the top falsework bents over the west Howe truss were lowered whole into the river, and both bents and truss floated around into position under span No. 2. This arrangement opened the west side of span No. 3 for river traffic at the same time it closed the west side of span No. 2.

After the barges had been sunk down to place them under the truss to raise it, the calculations as to the depth of water that would still be in the bottom of the barges when the 225-ton truss began to lift from its bearings, and also the height that the deck of the barges would be above the surface of the river in carrying this load (after all the water had been pumped out) were both verified within half an inch.

Fig. 6 shows the barges after the water had been let into them when they were in readiness to put under the truss.

FIG. 5.—SPAN NO. 3, WITH TRAVELER, AND WITH FALSEWORK CARRIED ON TRUSSES.
(The end of one of the old spans is seen at the right.)

It had originally been intended to also float one of the Howe trusses around under span No. 1, but the filling in of the east bank, before referred to, did not leave enough room to float the barges.

However, there was no foothold for piles under the west end of the span, so the girders which had been used under span No. 4, were floated across the river in pairs on a single barge. The falsework

which had been used under span No. 4 was then brought over and set up under this span without reframing.

Though the Howe trusses which were used in this work filled every purpose for which they were constructed, their maximum middle deflection under the greatest load ever brought upon them being only ⅝-in., the writer now thinks that perhaps it would have been better not to have used these trusses at all, but to have adopted some other expedient, such as proportioning the three 138-ft. deck shore spans to have done the work required of the three Howe trusses, and then they could afterward have been removed to their final places in the structure.

The Howe trusses were necessarily designed to carry unusually heavy dead loads as well as the usual live loads. They were expensive as to material, erection, and removal, and were of little service afterward.

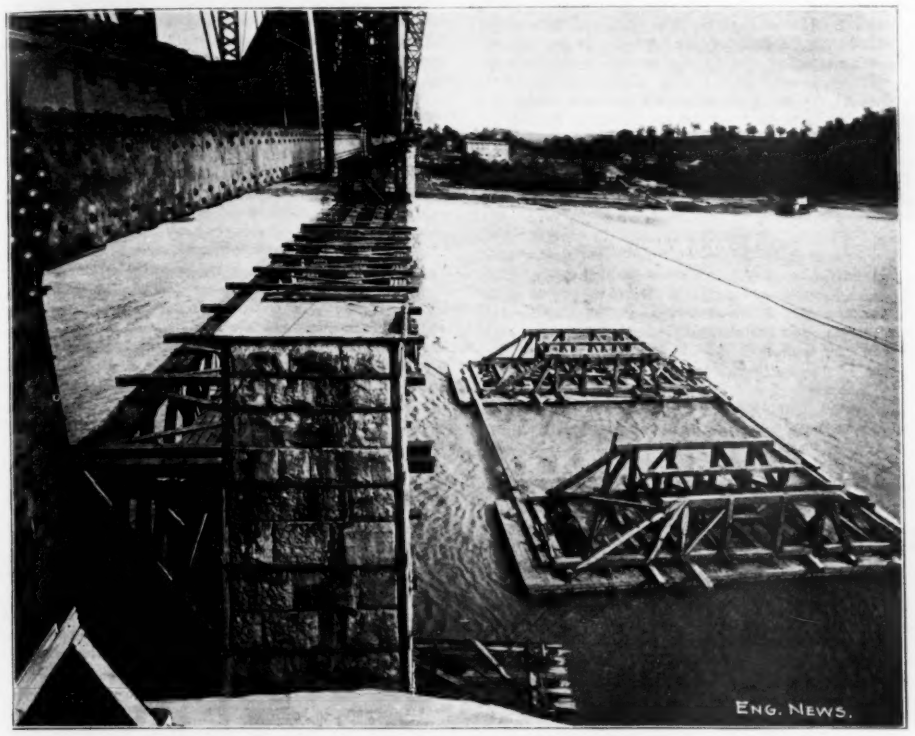


FIG. 6.—SCOWS FOR CARRYING THE HOWE TRUSS FALSEWORKS.
(In the foreground is one of the old towers of the pier, bound together with iron rods and bands.)

SECOND ANNUAL MEETING OF THE AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.

The second annual convention of this Association was held at Chicago on March 12, 13 and14; a full report of the proceedings will appear in our next issue, and we present below an abstract of the address delivered by Mr. J. F. Wallace, President of the Association, and Assistant General Manager of the Illinois Central R. R., and the reports presented by three of the standing committees of the Association, somewhat condensed from the original:

President's Address.

At the close of the second year in the life of this association the members have every reason to congratulate themselves on the results so far achieved. The mileage represented, the character of its membership and the enthusiasm with which the work has been undertaken assure a prosperous future. While the problems which the association has undertaken to solve are large ones, the manner in which it has commenced its work is a guarantee that in working out or at a solution of these problems much benefit will accrue to the railroads represented in this organization as well as to the individual members.

The hand-to-mouth method of managing railroads, particularly as applied to maintenance problems, is rapidly passing into disuse, and more consideration is being given year by year to the true economy of maintenance. In the ideal maintenance of any railroad property, the sums expended should not vary materially from year to year; the different classes of renewals should be made systematically and regularly, regardless of temporary fluctuations in earnings. The closer the management can get to regularity in its maintenance expenses, the more economical results will be obtained. The railroad situation in this country is rapidly approaching a condition of permanency, and, as owners and managers can predict from past records with reasonable accuracy their probable revenues, they should be able to closely estimate the sums required for future maintenance.

When the chief engineer, general superintendent or whatever officer has charge of the physical condition of the property, can lay before his general manager carefully prepared and accurate budgets of expenses for the year, as well as estimates of the normal amounts that should be spent on the different items, the haphazard methods of management in this respect will rapidly disappear and the work will be intelligently and satisfactorily handled to owner, manager and engineer. The worry of explaining why the expenditures in any certain month or on account of any one item were more than in the previous year will be done away with.

While there are some items, like renewals of steel bridges, rail, station buildings, etc., which cannot well be provided for with regular annual appropriations for renewals, the average amounts necessary for these renewals can be determined with approximate accuracy; and certain sums could be charged out and set aside to cover these extraordinary renewals. The minor items, such as repairs and renewals of wooden bridges or their replacement by more permanent structures, the widening of excavations, strengthening of embankments, renewal of ballast and ties, minor repairs to buildings and structures, fencing and the many items that enter into the repairs of road account, should, however, be approximately determined and the amounts expended therefor made uniform.

When the work is laid out and carried forward on some such basis, comparative statements will then be of more value, and the fluctuations above or below normal will be due to causes which can be determined and explained, and the comparative efficiency of different men in the economical handling of road department matters more reliably observed.

One of the questions which our various committees should determine, by the collection of facts from the experience of different roads and the sums expended by them on the different items of maintenance, is the approximate normal amounts for the proper maintenance of railroad properties. It is, of course, true that we should not be misled by averages, as conditions differ on the various roads, due to physical, climatic or traffic characteristics; but the consideration of this question along these lines will be beneficial and educational, and will very materially help both the officers having direct control of maintenance-of-way expenditures and the managements.

In these remarks attention has only been called to fundamental principles and the general lines along which this important subject of economical railroad maintenance should be approached. Above all things, we should give consideration to the proper relations between physical betterments and the purposes they are intended to serve. We should not fall into the error so many engineers make, of looking at their work from a technical standpoint only and endeavoring to rear the most substantial and perfect monuments to their skill; building structures to which they can point with pride as samples of their work, but losing sight of the fact that the ultimate aim of railroad construction and maintenance is to provide for the safe, expeditious and economical handling of traffic. To this end all other considerations should be made subordinate.

Report on Yards and Terminals.

Few railways are in a position to consider questions arising in connection with terminal work, free from the limitations imposed by ehe existence of facilities already established. It is believed, however, that many errors in design in such work may be avoided by the elucidation of the principles which appertain to the different branches of terminal service. The committee has carefully considered the practical points involved as well as the broad question of what would be the best practice apart from such limitations.

TERMS AND DEFINITIONS.

The first work was to consider the terms used in this branch of the service, with a view to the adoption of a series of standard terms, as well as to formulate definitions of these terms, in order to have a common understanding in the discussion of the various questions. It was found at the outset that even among the members of the committee the same term had different meanings, and different terms were applied to the same thing. From this original confusion there has been developed a series of terms and definitions, which it is hoped will gradually come into general use. The committee believes that this is of importance in establishing a foundation upon which to base the continuance of its work.

Ine of the first difficulties encountered was in regard to the too frequent and indiscriminate use of the word "Yard." This term is now generally applied to the single set of switching and storage tracks at small stations; to each of the several independent sets at large terminals or division points, and also to the entire series of such sets at the same points. Thus a "yard" may be composed of a number of "yards" (receiving, separating, classification, storage, departure, eastbound and westbound, etc.). Colloquially, this produced but little confusion, but it does produce confusion when the questions involved in yard design and operation come to be considered technically. After having encountered this difficulty several times, your committee concluded to take the radical step of adopting a new term to designate the entire series of "yards" at important points. The term adopted, after some discussion, is "Cluster," which, according to Webster's Dictionary, is "A number of similar things collected together or lying contiguous; a group." This definition seems fully to meet the requirements.

The word "Terminal" has been taken to include all the facilities provided for terminal work, on a large or small scale, while the word "yard" relates only to one set of the tracks which are used for the switching or storage of cars. Terminals may be divided into freight or passenger terminals, and may be further classified as line terminals, division terminals, district terminals, branch terminals, etc.

With these explanations, the following list of terms and definitions is presented:

Terminal.—The facilities provided by a railway for the conduct of its business at the end of its line, or of a division or a district.

Freight Terminal.—The special arrangement of terminal facilities for the handling of freight business.

Passenger Terminal.—The special arrangement of terminal facilities for the handling of passenger business.

Yard.—Three or more parallel tracks arranged in series for the convenient switching or storage of cars.

Receiving Yard.—A yard for the reception of traffic.

Separating Yard.—A yard next in order to the receiving yard, in which the traffic is separated by districts or commodities, as may be required.

Classification Yard.—A yard next in order to the separating yard, in which the traffic is classified in accordance with requirements, and made up into trains.

Departure Yard.—A yard next in order to the classification yard, in which trains are placed awaiting departure.

Storage Yard.—A yard in which cars are held awaiting disposition.

Cluster.—An arrangement of yards in series, for the separation, classification and storage of cars.

Gravity Yard.—A yard in which the movement of cars is produced by gravity alone.

Assisting Grade.—The elevation given one or more tracks of a yard to facilitate the movement of cars.

Poling Yard.—A yard in which the movement of cars is produced by the use of a pole or stake operated by an engine on an adjoining parallel track. The movement may be facilitated by an assisting grade.

Summit Yard.—A yard in which the movement of cars is produced by pushing them slowly over a summit, beyond which they run by gravity. The movement from the base of the summit may be facilitated by an assisting grade.

Body Track.—One of the parallel tracks of a yard upon which cars are switched or stored.

Ladder Track.—A track connecting in series the body tracks of a yard.

Lead Track.—An extended track connecting either end of a yard with the main line.

Drill Track.—A track connecting the ladder and used exclusively for movements in yard switching.

Open Track.—A track reserved for movements through a yard.

Running Track.—A track reserved for movements through a cluster.

Crossover Track.—A track connecting two adjoining tracks.

Special Tracks.—In a typical yard there will be several tracks devoted to special purposes, varying with the local

conditions. These will include caboose tracks, scale tracks, coaling tracks, ash-pit tracks, bad-order tracks, repair tracks, icing tracks, feed tracks, stock tracks, transfer tracks, sand tracks, depressed tracks, etc.

LOCATION.

The location of a yard or cluster depends primarily on the necessity for a readjustment of the formation of trains for purposes of distribution, and should be within reasonable distance of the areas which yield traffic for movement over the line or to which traffic arriving from the line must be delivered.

Within such limits as convenient and economical operation make practicable, the location may be adjusted to suit the topography of the ground so as to obtain the benefit of such natural advantages as may exist having reference to grades and drainage, also to cost of land and size and shape of sites available for the purpose.

More in detail, it may be said that the location should be convenient to the business terminals of the road, to the freight houses, team tracks and to the points of interchange with other roads or divisions, and should be arranged so that trains can enter and leave the yard without crossing the path of other movements. Where possible, advantage should be taken of natural grades to assist in switching. In some locations assisting grades cannot be had; in others grades can be had in one direction; while in others grades can be used to help in each direction. The assistance of grades is an advantage.

The size of the yard should be roughly estimated and the points available should then be selected. The cost of property, grading, drainage, etc., should now be considered, and the advantages and disadvantages of each possible location summed up; these figures should include cost of operation, interest on first cost, etc.

RECEIVING YARD.

In regard to the design of yards, the committee first took up the question of freight service at a line terminal (or the actual end of a railway company's line). Considering this matter in proper sequence, we have first the receiving yard, which receives the freight trains coming in off the road. Here the road engine and caboose are cut off, and the work of assorting and distributing the cars is taken in hand by the switching engines and crews. It is very generally assumed that the length of tracks in the receiving yard should be sufficient to accommodate the longest train entering the yard. This does not hold good invariably, however, for the reason that, where very few trains are of the maximum length, the adoption of the maximum length of tracks may involve unnecessary expense as well as an unnecessary amount of switching movements. Under such conditions of traffic it may be preferable to provide for the average train, leaving the maximum train to be taken care of by special means or special movements. The proper length of track for a receiving yard is a relation dependent upon the unit selected, and is governed by the following factors:

1, Length of train of loaded cars; 2, length of train of empty cars; 3, average length of trains; 4, No. of trains of average length per day; 5, No. of trains of maximum length per day.

Consideration should also be given to prospective changes in grade and to possible increase in the length of trains entering the yard.

The length of train is the controlling factor and the logical unit. When the trains of maximum length represent less than 20% of the total unmber of trains entering the yard daily, then the average train length will be the most practicable basis for a receiving yard having tracks of equal length. The yard may, however, be constructed with a portion of the tracks of sufficient length for maximum trains, and the remainder of the tracks of sufficient length for average trains. In this case, the tracks of each group should be of equal length. Whichever unit is taken (the maximum or the average train), the track should be of such length as to accommodate a train with two engines and a caboose. If the average train length is taken as the unit, then the length of track should be such that a train of the maximum length can be disposed of on not more than two tracks.

The proper size of the receiving yard is a relation dependent upon: 1, The frequency of the arrival of trains; 2, The rate at which cars can be received and disposed of in the separating yard. The committee lays down the principle, however, that the receiving yard should have a sufficient number of tracks to hold the trains arriving during one hour of maximum traffic.

SEPARATING YARD.

This yard is the second in the series, and here the first breaking up of a train and the distribution of its cars is effected. The cars entering the yard are usually distributed so that, according as the separations are to be by districts or by commodities, the cars destined to assigned districts, or containing the same commodities, will be placed together on separate tracks. The yard should be located in advance of the receiving yard, and in such a way that cars can be readily moved into it. The number of tracks in the separating yard should be governed by the number of separations to be made. The length of these tracks should be determined by the number of cars for each separation, and there should be extra room allowed for emergencies.

CLASSIFICATION YARD.

Here the second distribution or assorting of the cars is effected. When the separation in the preceding yard is by districts, the purpose of the classification yard is to put the cars of the different districts in regular order. Thus the cars of each district (already placed on one of the tracks of the separating yard) are switched in the classification yard in the order required for delivery at destination. When the separation is by commodities, the cars of each commodity (already placed on one of the tracks of the separating yard) are further assorted by classes or grades. Thus all the cars of grain, placed indiscriminately on a track in the separating yard, will be rearranged in the classification yard so that the cars of wheat, corn, oats, etc., are each grouped on separate tracks. The classification yard should be located in advance of the separating yard, and in such a way that cars may readily be moved into it from any of the tracks in the latter yard. It is usually in the form of a gridiron, and its capacity will be determined by the number of cars going to a district, with ample allowance for an excess number or for emergencies. As an example: With 36 cars going to a district, two "gridirons" of six tracks each, with a capacity of six cars to a track, will give such control of the entire set of cars that it can be turned end for end, or car for car. This type of yard may be made up of a series of parallel stub tracks instead of gridirons; such an arrangement is sometimes termed a lancing yard.

DEPARTURE YARD.

In this yard the trains made up in the classification yard are held awaiting departure. Here the work of the yard engines and their crews ceases, and that of road or transfer engines and their crews is commenced. It should be located in advance of the classification yard, so that cars from all tracks in the latter can be readily moved into the departure yard. The number of tracks and the length of tracks in this yard are governed by the same requirements as those governing the receiving yard.

STORAGE YARD.

This yard is for the reception of cars which have to be stored or held awaiting disposition, instead of being put into trains and sent forward. The location of the storage yard is very important and depends almost entirely upon the character of the cars to be stored or held. Three distinct cases may be mentioned:

1. On some railways, it is known in advance that entire train loads of business arriving will have to be held. In such cases, the storage yard should be located with or in close relation to the receiving and separating yards, so as to permit of direct movement of trains into the storage yard, and then into the separating yard as required.

2. The cars to be held may arrive mixed in with cars that are to go forward. In such cases, the storage yard should be so located in relation to the separating yard that the cars can be moved directly into the storage yard from the separating yard, and then delivered to the classification yard as required.

3. The character of the freight to be held may be such that it can be put in district and station order at once. In such cases, the storage yard should be located in such relation to the classification and departure yards that cars can readily be moved directly into the storage yard from the classification yard, and then delivered to the departure yard as required.

There are probably other cases, but we have mentioned three of the principal ones to indicate the fact that the location of the storage yard cannot be determined arbitrarily or theoretically, but must be dependent upon the character of the business in each case. The size of the storage yard should be governed almost entirely by the number of cars to be held, and the length of the tracks should be such that a switching engine can readily handle all the cars standing on one track.

POINTS TO BE OBSERVED IN THE LOCATION OF YARD TRACKS.

Having adopted terms and definitions for the various tracks required in yard work, your committee has taken the further step of laying down certain rules and principles governing the location and use of these tracks.

Body Tracks.—These should be spaced 11 ft. 6 ins. to 13 ft. c. to c., and while the minimum spacing is not to be recommended for general use, it is often desirable to use it for the purpose of utilizing the space in city yards to its fullest capacity. At intervals of five or six tracks an extra width of spacing should be given, in order to allow space for drainage and for the piling of track material, etc. It is also advisable to allow a space of 15 ft. between the center of a main track and a yard track, so as to give ample space for water columns or standpipes, signal-posts, etc.

Ladder Tracks.—Where there are two ladder tracks, or where another yard track parallels a ladder track, these tracks should be 15 ft. c. to c. The extra room is required for the safety of trainmen in throwing switches and moving in and out between the cars. The angle which the ladder track makes with the body tracks should be the greatest angle which the frog used will allow. No. 7 should be the minimum number of frog for yard use. Frogs of higher number are often preferable and are often used, but it must be remembered that the easier curves of such frogs require longer leads and consequently occupy more yard space.

Lead Tracks.—The connection of these tracks with the main line should be controlled by a telegraph office and interlocking plant, both for safety and to facilitate train movements.

Drill Tracks.—These tracks should be so located as to cause a minimum interference with other movements.

Open Tracks.—The tracks selected as the open track should be one that will enable movements to be made from one end of a yard to the other with the greatest convenience.

Running Tracks.—Tracks of this class should be located with the greatest care. Such tracks should be provided for movement in each direction, to enable yard engines to pass freely from one portion of the cluster to another, also for road and yard engines to go to and from the engine house and other points where facilities are located.

Crossover Tracks.—These should be located at the most convenient places, and where they will interfere as little as possible with regular movements.

Special Tracks.—In addition to the foregoing, there will be tracks required for special purposes, sufficiently indicated by their names. Several of these have been enumerated in the list of definitions already given, and particulars as to some of them are given below.

Caboose Tracks.—Cabooses arriving at a yard usually return over the same division, instead of going forward. It is, therefore, usually necessary to locate them between the receiving yard and departure yard, and to arrange them so that the cabooses can readily be pushed from a receiving track to the caboose track, and then dropped by gravity on to a train departing in the direction from which the caboose has arrived. There are various ways in which this can be accomplished, but in locating these tracks care should be taken that only a minimum amount of switching will be required. The tracks should be so arranged that cabooses feed forward, first in—first out. Occasionally special tracks may have to be provided for the cabooses of fast freight trains.

Scale Track.—This is usually located between the receiving and separating yards. This is undoubtedly the best location when automatic weighing is adopted, and no reverse movements should be required in taking the cars on and off the scales.

Coaling, Ashpit, Sand and Engine Tracks.—The engine-coaling facilities are usually located on the track leading to the engine house. Water and sand should also be taken at the same time as the coal, where it is possible to arrange this. The facilities for supplying coal, water and sand are sometimes provided on the outgoing enginehouse track, as well as on the incoming track. It will be of advantage to provide a run-around track, so that switch engines may clean fires, take coal and water and pass around waiting road engines.

Bad-Order Tracks.—These are required in order to get the bad-order cars out of the way of the switching movements, and they should be so arranged as to be easy of access at all times. From them the cars are taken to the repair tracks.

Repair Tracks.—These should be conveniently located, connecting with bad-order tracks, when practicable. They should be laid in pairs, 16 ft. c. to c., with space not less than 24 ft. between each pair for the handling of material. The length of repair tracks should not, ordinarily, exceed fifteen cars.

Icing Tracks.—These should be located between the receiving and separating yards, so that the cars to be iced may be readily moved from the receiving yard to the icing track, and thence to the separating yard.

Other Special Tracks.—The particular purpose for which such tracks are required should be carefully considered, and the tracks should be so located that their use will involve a minimum amount of switching, and the least possible interference with the regular yard movement.

In presenting this report, your committee desires to state that it has considered the designing of a yard with reference to the movement of traffic in one direction only. For movements in the opposite direction, a duplication of yard facilities will be required.

Yards should be provided for traffic in each direction. Most of the large yards of the country to-day are made up of only a receiving yard and a separating yard, the trains departing from the tracks of the separating yard. For classification, the cars are switched and then gathered up into a train at the leaving end of the yard. This method of yard work is very common, and is frequently the best that can be provided in most locations. It is, however, an expensive method of operation, with limited capacity, as compared with the results that can be obtained in a properly designed yard.

CONCLUSION.

Your committee directs attention to the terms and definitions prepared, and submits them for adoption. It has endeavored in this report to lay down the general principles and some of the special requirements which must govern yard design. The principles and requirements here given cover the entire series of yard movements (for engines, cars and cabooses) from the entrance of a train into the yard to its departure therefrom. There are many other matters of importance in connection with yard and terminal work, which will receive the future attention of the committee.

A. W. Sullivan, Ill. Cen.; J. W. Thomas, Jr., N. C. & St. L.; I. G. Rawn, B. & O. S. W.; E. E. R. Tratman, "Engineering News;" R. B. Tweedy, Wis. Cen.; S. P. Hutchinson, Pa. R. R.; J. B. Cox, Chi. Junction; C. W. Hotchkiss, Con. Engr.; C. S. Sims, Jr., Pa. Lines; W. S. Kinnear, Mich. Cen.; J. A. Atwood, P. & L. E.

Report on Graduation.

This term in intended to embrace the preparation of the ground, the excavation and placing of the material, and other general work incident to the formation and maintenance of the railway roadbed and yards. The committee has made an analysis of the drawings and specifications of representative railways in all parts of the country, and the fact intimated in last year's report that great dissimilarity exists in standards, even under similar general conditions, is much emphasized by this analysis.

Some roads use no general standards in regard to cross-sections, or have standards which exist only on paper; others have plans which have been in use 30 or 40 years without revision to meet modern requirements of loads and speed. Some have standard sections, the general principles of which are the same as those used by a larger system, but which have been slightly altered without apparent reason—and frequently to the disadvantage of the road making the change. Others have admirable plans, with ideas carefully thought out, but which leave room even yet for modification or amplification, while still others have plans in which the cost of the work represented is beyond the financial resources of ordinary roads.

In many instances a needless refinement is exhibited in regard to the shape of the roadbed at sub-grade, viz., a curve, series of curves, or a series of planes at various angles, shapes which are not easy to make and maintain, and are rarely adhered to in actual practice. Simple drainage planes or a uniform slope of 0.04 per ft. falling from each side of the center line of roadway are easy to make, and are found to be effective.

The width of roadbed is generally too narrow; 20 ft. on embankments, and a corresponding width between ditches in cuts, should be taken as minimum for single track, on what may be termed a first-class road, with an addition of 13 to 14 ft. in case of double track. The surface ditches in cuts should be kept well below the intersections of the sub-grade planes with the planes of the slopes of the cut, and the shape such, as can most economically be maintained. Surface ditches on curved portions of the road should be on the same level, the inclination of the track being made up in the ballast.

On preliminary and location profiles, the several descriptions, or the nomenclature indicating the classes of material or the kinds of ground, are frequently imperfect or misleading for the proper determining of the most suitable slopes, and the best methods of dealing with unstable ground upon which embankments are to be constructed. The engineer of location should therefore not only possess a thorough practical knowledge of the condition and physical composition of every class of soil and rock met with, but be precise in recording it.

To insure substantial embankments, much depends upon four important features: 1. Proper clearing and grubbing of the ground to receive the earthwork. 2. That the nature of the ground is either suitable for supporting the fill which is to overlie it, or can be made so by drainage or otherwise. 3. Placing of excavated material in the most suitable locations with regard to greatest frictional resistance in masses. 4. Trimming to the slope adopted.

In embankments of 2 ft. or less in height, the whole of the space occupied should be thoroughly grubbed out, and where they are more than 2 ft. and less than 4 ft. all trees and stumps should be cut at least 2 ft. below sub-grade.

In preparing unstable ground for the embankment, it should be subjected to the closest examination as to its nature, with a view to remedy before placing material upon it. Preliminary drainage is frequently all that is necessary. If the land is swampy, with a thin crust of insufficient strength for the weight to be supported (commonly called a "sink hole") it may be necessary to continue filling in material until a solid foundation is obtained, in order to secure a roadbed that can be used with undiminished speed, but there are numerous other methods, each depending on local conditions.

If the swampy material be on a side hill, it should first be drained by means of a side ditch on the upper side parallel to the roadway, and the water led off to the lower side by means of cross drains. A case has been noted in which a swamp or bog of about half a mile in length is being crossed by a line at present under construction. This swamp or bog consists of a black soil somewhat like peat in its nature, which holds the water tenaciously. A ditch on either side of the embankment at a distance of 75 ft. from the centre line was excavated down to the sand and gravel, a depth of 3 to 6 ft., but the water still stood between these ditches, and the bog material was about as impassable as before the ditches were cut. Cross trenches were then cut at intervals of about 50 ft., and boxes of 3-in. plank, open at the bottom, were put in, with a result that the ground has now dried up sufficiently to enable the material from the adjacent cuts to be hauled on to it, and from present appearance, it is anticipated that the weight will squeeze the water out of the blocks of ground into which this is divided, and eventually give a dry and good roadbed.

The material excavated from cuttings should be built up in the embankment evenly, and in horizontal layers not exceeding 3 ft. in height, each layer being carried out to full width at the particular height, and any stone or heavy materials should as far as practicable be placed at the base of slopes. The best soil should be reserved for outer dressing, in the event of subsequent sodding or seeding.

Cases have come before the notice of the committee where great trouble and expense has been caused by defective banks due to sliding of the material in large masses. Investigation by cutting the bank revealed the fact that when originally constructed, borrowed material of heavy blue clay had been deposited at the base of the embankment with an inclined top plane, and overlaid with surface material from cuts, and that there was a well-defined line of cleavage between the two materials. The sliding of the embankment occurred on this plane, and it may reasonably be inferred that if it had been built up level, such sliding could not have taken place.

Much depends upon homogeneity in the mass of the fill, and to this end it is advisable (especially in woodland districts where there is frequently a leaf mould overlying a substantial sub-soil) at the end of cuttings, to strip the surface soil, if it is light and porous, to a depth of 18 or 20 ins. below the grade line, and dump the portions of soil thus stripped into fills which would be a greater depth than 2 ft. below grade. By this means, the sub-soil material in the portions of the roadbed immediately below grade would be continuous from excavation to embankment. Homogeneity in the mass is naturally a check against large moves, and at the top it is especially felt by giving a uniform firmness during summer, and a greater freedom from heaving in winter.

Experience shows that the slopes of cuttings, and more especially of embankments, when they attain their permanent form, are not the surfaces of planes, but more or less curved—a rounding off at the top, and a curving out at the foot. This being the ultimate natural result, it is best at the outset, when it can conveniently be done, to further its attainment by rounding off these angles.

Allowance for shrinkage of embankments of 3 to 7% according to material should originally be made. It would be better to provide for this shrinkage by making the roadbed wider than standard, instead of adding to the vertical height, so that when settlement takes place, there will be width enough to fill out, and not unduly run down the slope.

Where embankments are made on a side hill, deep furrows should where necessary be plowed in the slope, in order to bind the new material thoroughly to it; and in the case of widening for double track, and sidings contiguous to the main line or in other similar circumstances, it is best if the banks are over four feet high, to give them similar treatment.

The fundamental principle in maintenance is to keep the roadbed dry, and to insure this every reasonable means should be employed to intercept the natural course of water from outside sources that would otherwise reach the roadbed, and then if by this means, a sufficient degree of dryness is not attained, sub-drainage should be employed.

The surface ditches at the foot of slopes in cuttings being for the purpose of draining the roadbed, and also for the purpose of protecting it by intercepting and carrying off the accumulation of surface water on the slopes from rain, and that due to seepage, they should be of sufficient capacity to take off readily the water from the heaviest rainstorm, and of such shape as can most easily be cleaned from time to time. In ordinary cuttings, a ditch 9 ins. deep, 12 ins. wide at bottom, and slopes of 1½ to 1, generally meets these requirements. A true grade should be preserved for the bottom of these ditches and the greatest possible pitch given at their outlet.

In wet cuttings a supplementary sub-drain of 6 to 10-in. tile is of great advantage to the maintenance of track. A trench is excavated to just below frost line, in which the tiles are laid with ends abutting, engine cinders are placed over the tiles to a depth of two or three inches, and the remainder of the trench filled with coarse gravel or broken stone.

In cuts through ground sloping transversely, a ditch should be made on the upper side, to intercept the surface water which would otherwise flow over the slope; but the distance to make this ditch from the edge of the slope, as well as its general characteristics, must receive due consideration, for the soil may be of such a permeable nature, and become so saturated with water from this ditch, that injury will result to the slope. It is often better to have a broken stone or tile drain on the top of the cut to collect and carry off the water, or else pave or box the ditch to prevent damage from the water cutting through the slope. In every case, however, where the general ground is sloping towards the cut, the nature of the soil should first be thoroughly examined, local conditions noted, and the main source of supply stopped or diverted where possible.

PROTECTION OF SLOPES.

Protecting the face of slopes on the older and more important lines is receiving much attention, and where done has been generally beneficial, and added much to the appearance. Sodding is the best and simplest method, if it can be well started and has sufficient proper soil to subsist upon. In most cases the extra expense of sodding, especially at time of original construction, will be made up in a few seasons by the security it gives against heavy maintenance charges. Sods from high well drained ground are the best, as those from swampy localities are apt, if exposed to the sunny side of a cut or fill, to dry out rapidly and disintegrate; still the latter can be used to advantage on the shady side of slopes, but the former are more resisting from their previous condition of growth. Sods for transplanting are best when about five years old, but in laying, extreme care is needed, and they should be secured by slender hardwood stakes driven well down into the ground, where the material on which they are laid is inferior.

Supplemental to the sodding, improved results can be obtained if for the first year a good mixture of timothy seed and oats be sown; it quickly forms strong roots and helps to hold the sod in place; afterwards, as may be needed, a mixture of Kentucky blue grass, white clover, perennial rye, red fesco, and red top in the proportion of 8, 4, 9, 3, 8, respectively, making thirty-two lbs. per acre.

Before sodding is begun, the slopes should be dressed to a reasonably fair shape. It is practically useless, however, to attempt sodding on unstable clay slopes which slide so deep as to carry away both sods and pegs, or on poor soil or barren slopes on which it soon burns out. When such conditions exist, other methods have to be adopted.

In warm climates, slopes of embankments composed of sandy material may be successfully protected by setting out on the embankment small tufts of Bermuda grass, planted about 18 ins. apart in each direction, the sod being collected and cut into pieces about 6 ins. square. It is found that such frequently makes a substantial sod of Bermuda in 12 months.

Grass seed alone, even if the soil be fertile, is difficult to start on account of liability to washing away during rainstorms, but where it can conveniently and economically be used, it is well to do so. Manure from stock cars and cattle pens, as well as street sweepings which contain a large percentage of seed of various kinds, have been successfully used in producing an effectual sod in a couple of seasons.

Excellent protection on some soils, such as silt or slippery clay, and especially as a guard against washing, where the embankment is alongside the course of a stream which rises and falls considerably, is attained by planting willows. Such trees or shrubs are well adapted for the purpose, as they grow quickly and are easily propagated from cuttings, and their masses of fibrous roots spread through the soil to a great depth, and hold the bank tenaciously.

There are many banks in which protection has been furthered by placing blind drains in the slopes at right angles to the line of track, consisting of loose rock put in ditches about 3 ft. wide and 4 ft. deep. Most of these banks had sloughed out more or less, and this sort of protection is an added feature, frequently after long use of the embankments; these broken stone drains serve the double purpose of carrying off sub-water, and acting as buttresses for the support of the embankment.

In some heavy cuttings through light sandy soil, the faces of the slopes have been protected from the action of the wind by covering them with a layer of clay from 4 to 6 ins. thick. In this soil grass and small shrubs take root, and serve still further to protect the slope. In sandy soils, good results are also obtained by spreading engine cinders over the slopes of embankments and cuts, and very little washing away of the soil then takes place.

RETAINING WALLS.

These are used to protect the sides of cuts and fills against continual slidings, by building up and then lessening the slope; to curtail the spread of the slope of embankments on steep side hills, and that of cuts and fills where streets in towns are contiguous, or where land value is a vital matter of expense; they are also used in certain cases to prevent abrasion of the embankment by water, either by current or waves. In fills, the walls are generally built in such location as to require the least masonry, and in cuts, the distance of face of wall should not be less than 7 ft. from the outside of the outside rail.

Permanent retaining walls are principally of masonry or concrete, or of both, the selection of the material being dependent on local conditions. They should generally have a batter of not less than ¼ to 1 (although in some cases, as in cities or towns, they may have to be plumb), and be from 2 to 3 ft. wide on top, with base 0.4 to 0.5 the height, dependent on the condition of the ground back of the wall, and the quality of the masonry. Drainage of broken stone or coarse gravel should be properly provided at the back of the wall, if the soil to be supported is retentive of water; but if the ground is of clean sand or gravel, this special drain need not be made. Ample weep holes should in all cases be placed in the wall, otherwise there may be disastrous failures, and there should be a drain in front of the wall, and parallel with it, to receive the output of these holes.

IMPROVEMENT OF GRADES AND ALINEMENT.

These may be classed under two heads: 1, A complete change of location; and, 2, the lessening of the grades and

modifications of the curvature, as nearly as can be on the existing location.

In either case the haulage features of each should be well worked out in connection with probable cost, in order to form an intelligent opinion as to the relation of future value to capital expended. This part of the problem is freer from variable and complex factors than is the determination of locomotive efficiency, and what is required in that respect is a rational and adequate method for calculation in adopting a consistent and economical policy in grade revision. The present policy of many railways is undoubtedly erratic, and wide of economy, because of the failure to consider all the factors that apply to a logical solution of the problem.

The value of momentum in surmounting grades taken into consideration in calculating "virtual" or "equivalent" grades must not be lost sight of, as cases of increased load as high as 15% have frequently been met with, when advantage was taken of the momentum; and grades should also be so revised, that in overcoming the heaviest, there will not be an undue excess or waste of power on the lighter ones.

The maximum grade and curvature should be decided, and the necessary compensation calculated for the curves, to make the resistance on them equivalent to that on a straight line. For example, on lines where tests have been carried out on an extensive scale, it has been found that 0.03% for each degree of curvature for all curves up to and including 2°, 0.04% above that and up to 5°, and 0.05% above 5°, and up to 10°, is good practice. For a high speed line, all curves 2° and above should be spiral, taking a speed of 50 miles per hour, but in no case should the superelevation of the curve be more than 8 ins.

The tonnage in each direction should be figured out, as in some cases it may be practicable to adopt a heavier controlling grade in one direction than the other, according to the character of the traffic.

W. McNab, Grand Trunk Ry.; C. Dougherty, Illinois Central R. R.; R. C. Barnard, Pennsylvania Lines; H. Baldwin, C., C., C. & St. L. Ry.

Ballasting.

That ballasting is of great importance, when considered from an economical standpoint, can be readily shown by a few figures taken from the report of the Interstate Commerce Commission. In 1899, $522,967,896 was paid out in wages to the officers and employees of the railways in the United States. Of this amount, $79,264,280, or a little more than 15%, was paid to trackmen alone. Assuming that 40% of this amount was paid for lining and surfacing, you have the immense sum of nearly $32,000,000 paid out for labor in keeping up the line and surface. The total expenditures on account of maintenance of way and structures in 1899 amounted to $169,825,054, or about $902 per mile of road. Of this, $32,000,000, or $168 per mile of road (or 19% of the total maintenance of way and structure expenditure), was on account of line and surface. When we consider how much of this great outlay was probably due to inadequate ballast, we feel that the subject is well worth careful and exhaustive study.

Mr. Feldpauche, Principal Assistant Engineer, Pennsylvania R. R., in his report made to the International Railway Congress, says:

> By way of introduction, it would seem appropriate to assert that good ballast should consist of such materials as would best insure a substantial, enduring, dustless and somewhat elastic foundation for the track. It should be substantial, so as to distribute the strain of passing loads upon the largest possible area over the underlying roadbed, thereby reducing to a minimum the depressing tendency of ties. It should be enduring, so as to lessen, as much as possible, its destruction from tamping and the expense thereby entailed for its renewal. * * * It should be dustless, so as not to discomfort the passengers or heat the frictional parts of the running equipment. Finally, the ballast should be somewhat elastic, so as to lessen the shocks and thereby reduce the wear and tear upon rails and trains.

Mr. Bauchal, Assistant Permanent Way Engineer of the Western Railway of France, in his report to the Congress, defines the functions of ballast thus:

1. It gives the track a suitable support and fills up inequalities in the formation level.
2. It distributes the pressure upon the formation level and reduces the pressure per unit of area.
3. It acts as an elastic support to the track.
4. It resists the lateral displacement of the track, both through its mass and through friction.
5. It resists longitudinal displacement of the track.
6. In case of certain formation levels, it acts as a protection against frost.
7. It protects the ties against excessive dryness or excessive dampness.

Our own chairman, in his report to the association a year ago, said:

> Ballast may be defined as the material above the roadbed, in which the ties are imbedded, and its object is to get a solid and uniform bearing for the ties, to distribute the applied load over a large surface of the roadbed, to hold the ties firmly in position, to give elasticity to the track and to allow the water to pass off freely, thus avoiding churning in wet weather and heaving by frost.

You will notice that none of the foregoing descriptions of ballast and its functions, except that of our former chairman, say anything about drainage, which we believe to be one of its most important functions. There is one word used in all these definitions that we do not think to be well chosen. That is "elastic." Elastic means something springy, and we certainly do not want that in our track. The conditions desired is that it shall not be rigid or unyielding, but shall be to some extent flexible or pliable; we believe "pliable" more nearly describes the condition we desire, and will use that word hereafter instead of elastic.

Material for ballast must be substantial, so as to distribute the applied load; it must be enduring, to resist as far as possible destruction from tamping; it must be pliable, to diminish the shock and consequent wear of track and trains and permit of easy manipulation in lining and surfacing; and it must, above all things, provide thorough drainage.

Earth or dirt will fulfill none of the above requirements, and we do not think it should be designated ballast; we consider earth or dirt ballast to be a misnomer, and that track put up with it be called earth or dirt track. So far as our present knowledge goes, the only materials which will fulfill the requirements are broken stone, gravel, sand, burnt clay, slag, cinders, burnt shale and chatts. The requirements as to quality, size, etc., and the comparative merits of the different materials will be considered later in the report.

Now that we have decided what materials will make ballast, it remains to determine, in a general way, how much is necessary to constitute ballasted track. Our opinion is that nothing less than 8 ins. of ballast under the ties, with the track filled in, will fulfill the requirements even under the best of conditions as to roadbed, climate, drainage, etc., and that below this minimum track should be designated as partially ballasted or veneered; partially ballasted, when there is a sufficient depth under the ties but the track is not filled in; and veneered, when the track is filled in, giving the appearance of ballast, but with very little under the ties.

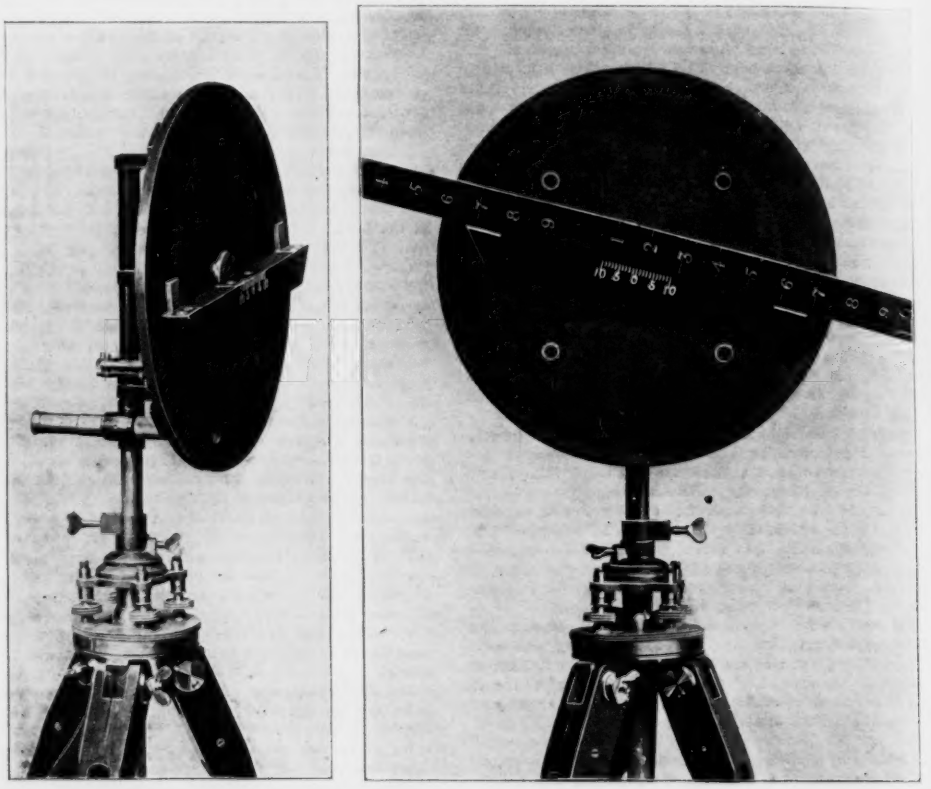
To summarize, the term "ballast" shall only apply to broken stone, gravel, sand, burnt clay, slag, cinder, burnt shale and chatts, and the expression "ballasted track" only to filled-in track, with not less than 8 ins. of ballast under the ties.

F. T. Hatch, Vandalia Line; F. A. Molitor, Choctaw, Oklahoma & Gulf R. R.; J. T. Richards, Pennsylvania R. R.; H. U. Wallace, Illinois Central R. R.; A. Mordecai, Erie R. R.; Edward Shelah, Philadelphia & Reading R. R.

THE "SUNFLOWER" TUNNEL CROSS-SECTIONER.

As engineers well know, the testing, or cross-sectioning, of tunnel work is a tedious operation under ordinary methods and where accuracy is required. In the construction of the Croton Aqueduct, Mr. Alfred Craven, M. Am. Soc. C. E., and now Division Engineer for the Aqueduct Commission, suggested a form of instrument for this work that has been put upon the market by Heller & Brightly, instrument manufacturers, of Philadelphia, Pa. The original instrument employed on the Croton Aqueduct was fully described in Engineering News of July 26, 1890, but its design and construction have been modified considerably, as will be seen by comparing the accompanying illustration with that published in our previous article. For this reason, and also because it is an unusually compact and convenient device for its purpose, we describe it briefly in this issue.

The prominent feature of the instrument is a wooden disk, 14 ins. diameter and ¼-in thick, braced at the back to prevent warping; and from this disk the device takes its trade-name of "Sunflower." This disk, graduated on the front to degrees, numbered from 0 to 180, is supported vertically by a tubular rod, on an extension-leg tripod fitted with a quick-leveling head. Attached to the center of the disk is a revolving, metal-shod wooden "indicating arm;" and on this arm slides a graduated tapering wooden rod either 8 or 14 ft. long; these rods, however, may be of any length; those used on the Rapid Transit Tunnel, in New York, are 20 ft. long. Through the disk and attached to the tubular support is a horizontal sighting tube, with cross-wires, which enables the user to set the center of the disk accurately upon the tunnel axis.



Side View. Front View.

A NEW INSTRUMENT FOR MEASURING TUNNEL CROSS-SECTIONS.

In use, the tubular support is set exactly plumb by two small levels at right-angles to each other, the disk can then be adjusted to any height and secured by clamp-screws; and with its center upon the tunnel axis, the measuring rod placed on the indicating arm, measures the distance between the center of the disk and the perimeter of the tunnel at as many points in that plane as may be desired.

The disk with its attachments weighs 10 lbs.; and the tripod and its head weigh 10¼ lbs., making 20¼ lbs. of total weight. In the Croton Aqueduct tunnels, from 6 to 10 minutes were sufficient for measuring a section. As the angles and distances are conveniently plotted with a protractor, the area can be measured with a planimeter. This device is also useful for testing masonry arches, after the centers are struck; and for this purpose a vernier is placed upon the indicating arm for more precise measurement